Swann
A

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*

JOSEPH ASHBROOK, *Technical Editor*

Vol. XIX, No. 4 FEBRUARY, 1960

CONTENTS

COVER: The 36-inch reflector of Leiden Observatory's southern station near Pretoria, South Africa. It has a spherical primary mirror with a Cassegrainian-type secondary, and is designed to provide rapid automatic photoelectric measurements of stars in five different colors. For this, five photomultiplier tubes are used simultaneously in the "spectrograph," which is permanently attached to the side of the main tube. The observer shown is T. Walraven, station director. Leiden Observatory photograph. (See page 205.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Second-class postage paid at Boston, Mass.

Subscription: $5.00 per year in the United States and possessions; $9.00 for two years; $13.00 for three years. To Canada, Mexico, and all countries of the Pan American Postal Union, $6.00 for one year; $11.00 for two years; $16.00 for three years. To all other foreign countries, $7.00 for one year; $13.00 for two years; $19.00 for three years. Canadian and foreign remittances should be made in United States currency. Single copy 50 cents. Back numbers, as available, 50 cents each.

All notices of change of address must be sent one month in advance and accompanied by old and new addresses. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. Return our bill form with renewal payment. Circulation manager, Nancy R. Bolton. Office staff: Virginia K. Cox, J. Caroline Nason, Mary Silva, John Simmons, Helen B. Sniegiecki, Stacia Strong.

Editorial and advertising offices: 49-50-51 Bay State Rd., Cambridge 38, Mass. Advertising rates are listed in STANDARD RATE AND DATA SERVICE, or sent upon request. Advertising manager, Henry M. Corrado. Editorial assistant, William E. Shawcross.

Unsolicited articles and pictures are welcome, bearing adequate return postage, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited material. The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

An Amateur's Night Out

FOR his night out, the amateur stargazer will need a good telescope, its size being limited by what he can afford to pay and by how heavy an instrument he can lug. He will probably settle for a 6-inch reflector or a 4-inch refractor. He will also need a site reasonably free from trees, buildings, and the lights of the city.

The night must be dark, the air may be cold, and it is best for him to be alone. These are the conditions imposed upon him, yet they are not impositions. But how can he explain this to the nonstargazer?

Must it be dark? Certainly. The darker the better. He does not want the silvered, romantic light of even the mellowest moon. Cold? Perhaps, for the winter stars and constellations are the most brilliant. But he dresses for it – long underwear and ski pants, heavy lined boots, and ear muffs.

Why best to be alone? Actually, the solitary stargazer, out there with his scope and red flashlight and charts, is not alone at all – he has only to look up at the sky, and he is in tremendous company. But, although he would love to share his findings and his night's bag of game with another hunter, each one should have his own telescope. If one of them painstakingly gets the vague wisp of a Messier planetary nebula or globular cluster on the crosshairs of the finder, the second viewer could easily jiggle it out of the field.

However, for any chance audience the amateur observer is always delighted to line up his showpieces – the moons of Jupiter, Saturn's rings, the Great Nebula and Trapezium in Orion, or the Double Cluster in Perseus. He can always give a little lecture at the grade-school level. But soon his audience departs, feeling fully informed on astronomy, or goes indoors to get warm.

He is left alone outside, to search after tiny M55 where low-swung Sagittarius merges into the vague reaches of Capricornus; or, in the winter night with the moon gone, he may at last find M74, the very faint wisp of light in Pisces. And if he doesn't find it, on a less-than-perfect night, he can split the Gamma star in nearby Aries, and marvel to himself all over again that so meek and undistinguished a speck can be separated into two shining, starry components.

The amateur's test of clear skies on a questionable autumn or winter night can be M1, the Crab nebula, just off the easy Zeta star of Taurus. If the Crab floats across the field, evanescent and lacy as a snowflake, then his chances of finding M74, or even M77 in Cetus, are good. He knows that the Crab is the remnant

(Continued on page 220)

Sometime during this two-hour exposure of circumpolar star trails, made by the late English astronomer W. J. S. Lockyer, a meteor of fluctuating brightness passed close to Polaris, marked by the short bright trail near the center.

Visual Observations of Meteors

OTTO STRUVE

*National Radio Astronomy Observatory**

ON NOVEMBER 13, 1866, the director of Pulkovo Observatory in Russia, my grandfather Otto Struve, was seated with his family at supper. Suddenly one of the telescope attendants, a retired soldier, rushed into the room and exclaimed:

"Your Excellency, the stars are falling from the sky, and we shall all be out of our jobs if this continues!"

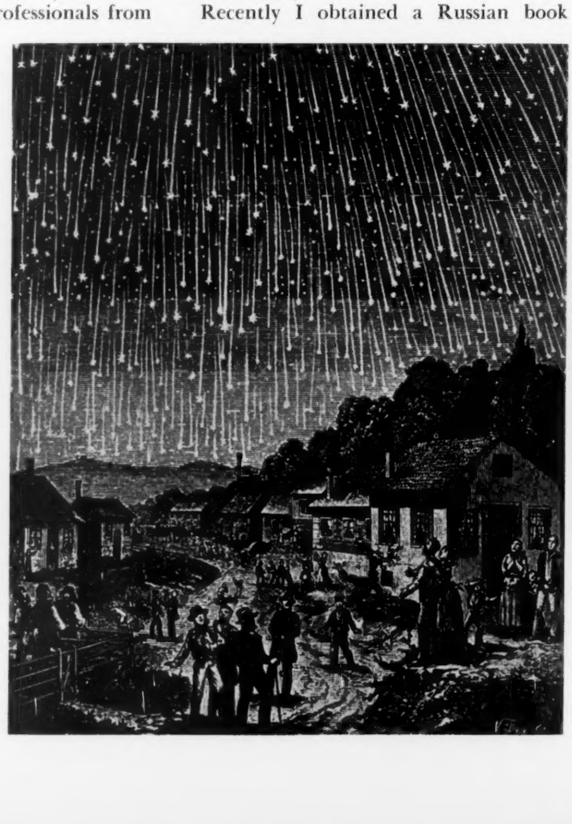
On that night the earth passed through the dense swarm of meteors known as the Leonids, which produced one of the most spectacular meteoric displays in history. Later, H. A. Newton found that this display had been recurring at intervals of 33 or 34 years since at least as early as A.D. 902. The hourly number of Leonids in 1833 was stated to have been about 200,000. Between 1866 and 1899, however, the compact swarm passed near Jupiter and Saturn, and its path around the sun was altered enough so no spectacular displays occurred in 1899 or 1900.

Since then, the earth has passed through the outermost fringes of a diffuse swarm, and only a few Leonids are seen each year about November 15th. The faint comet 1866 I, discovered by W. Tempel, was found to be moving in the same orbit as the Leonids, but it has subsequently disappeared.

First inspiration in astronomy has come to many amateurs and professionals from the casual observation of a bright meteor or fireball. A few, including myself, have become so fascinated with remarkable showers, such as the Perseids during the first two weeks of August, that they watch them year after year, recording their frequencies and plotting their paths on suitable charts.

While it is true, as F. L. Whipple and G. S. Hawkins say, that to a very large extent "the study of meteors has passed from the hands of the amateurs into those of the professional astronomers, the ballisticians, the electronics experts and other groups of scientists and technicians," certain carefully planned visual or photographic observations of meteors can still add important information to this field of astronomy.

Recently I obtained a Russian book



The Leonid meteors furnished a dramatic show on November 13, 1833, pictured here in a contemporary print. The richest part of the shower was seen from the southern United States, whereas the 1866 Leonid shower reached its peak during nighttime hours for European observers. Earlier, a spectacular rain of Leonids was seen on November 12, 1799, by Alexander von Humboldt in Peru.

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

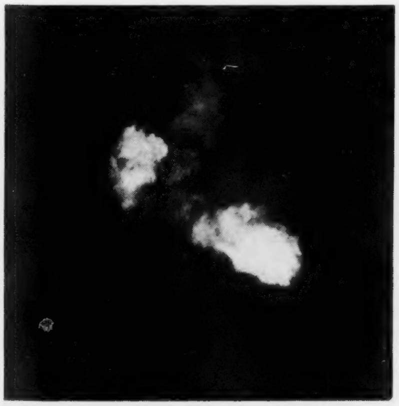
by I. S. Astapovich, of the Ashkhabad Observatory. Entitled *Meteoric Phenomena in the Atmosphere of the Earth,* it would serve Americans as an excellent introduction to meteor observing if it were available in English. Some of its contents will be summarized in this article, but our discussion will also include other scientists' results, especially those of Whipple and Hawkins in their article in Vol. 52 of the new *Handbuch der Physik.*

Edmond Halley described one fireball that appeared in 1718 as so bright it extinguished not only the stars but the full moon. The giant fireball of 1948 that produced the "rain of iron" in the Sikhote-Alin Mountains of eastern Siberia appeared on a clear day, producing moving shadows in addition to the shadows cast by the sun.

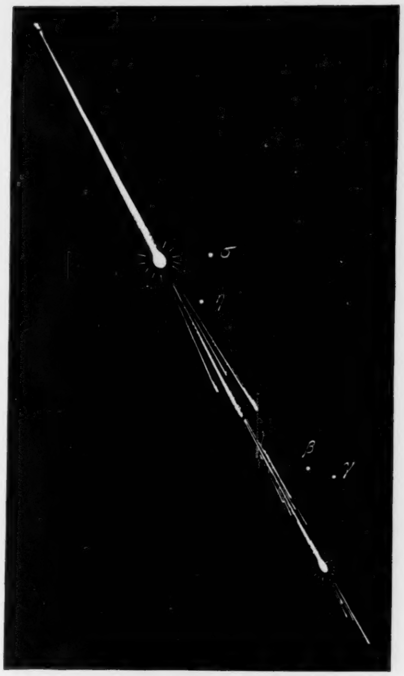
Such exceptionally brilliant fireballs, rivaling the sun in brightness, are of course very rare. Astapovich reports that, among 37,000 naked-eye meteors he has observed, only 87 were of apparent magnitude −4 (like Venus), and only two attained −12 and −14 (comparable to the full moon). This experience indicates that an average person might expect to see a *really* bright fireball only once or twice in his lifetime.

Because of the exceeding rarity of fireballs as brilliant as the sun, reliable observations of their paths across the sky, of their brightnesses, and of their visual appearances have great value. Many of them have an easily recognized angular size, and they often explode into numerous fragments while in flight. Usually long-lasting trains are left in the sky, appearing as clouds of dust during the day or as luminous streaks at night.

About five per cent of all fireballs produce noise like thunder, with shock waves that in some cases break windows or crack walls of buildings. At Madrid, on February 10, 1896, "A minute and one half



On February 18, 1948, the explosion of a large stony meteorite in the daytime sky over Norton County, Kansas, produced this luminous cloud, which was photographed three to five minutes later by J. W. Lewallen. The cloud is beginning to dissipate in winds of the upper atmosphere.



A disintegrating fireball in Hercules was observed on August 8, 1926, and sketched by I. S. Astapovich, from whose book a number of illustrations in this article have been reproduced or adapted.

after the flight of a brilliant daylight fireball, there was heard a tremendous explosion resembling the sound of thousands of cannon, after which there were several weaker explosions. The earth began to tremble . . . many buildings were damaged . . . millions of windows were smashed. Panic spread among the population. . . ."

The relative number of meteors increases sharply with decreasing apparent brightness, and the hourly rate of ordinary meteors seen by a single observer on an average nonshower night is about 10. During a fairly intense shower the rate may reach several thousand per hour.

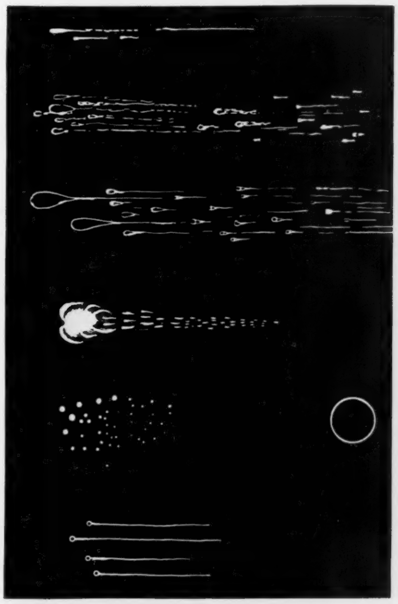
Astapovich estimates that for every meteor of apparent visual magnitude −25 there are 24 of magnitude −20, as well as 600 of magnitude −15, 15,000 of −10, and 10 million of zero magnitude. About 500 million in all would be brighter than magnitude +5, about as faint as the eye can see.

Telescopic meteors are even more numerous, but the faintest ones — usually also the smallest in mass and radius — are probably not as common as an extrapolation from the foregoing data might suggest. Very likely, the smallest particles are driven out of the solar system by the pressure of the sun's radiation, and by other effects. On the average, within a volume of interplanetary space as large as the earth, there may be some 60,000 objects that can become naked-eye meteors on passing into the earth's atmosphere. As our planet sweeps up this volume in about five minutes as it moves around the sun, the total number of meteors thus collected in 24 hours is about 20 million.

Some other astronomers find an even more rapid increase in the number of faint meteors than Astapovich cites. His data indicate that for each meteor of a particular magnitude there are two of the next fainter magnitude. However, Hawkins and E. Upton, from Harvard Observatory super-Schmidt photographs, have deduced the ratio to be 3.4 rather than two. Their data imply that 90 million meteors brighter than magnitude +5 enter the atmosphere of the entire earth each 24 hours.

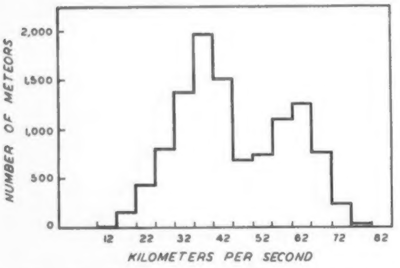
It is now well established that the vast majority of all observed meteors are members of the solar system and not intruders from interstellar space. Such an interloper would be moving in a parabolic or hyperbolic orbit, with a velocity of at least 42 kilometers per second when it is at one astronomical unit from the sun. Since the average orbital speed of the earth is 30 kilometers per second, interstellar meteors colliding head on with the earth should have relative velocities greater than 42 + 30 = 72 kilometers per second.

However, Whipple found that "of some 500 well-determined photographic meteor orbits none have yet been found to be certainly hyperbolic." In England, Miss



Sketches presented by Astapovich to depict (top to bottom): 1. Meteor on April 23, 1930, observed by S. M. Selivanov in a 7-inch refractor. 2. German fireball of September, 1924. 3. Fireball observed by J. Schmidt with low power, October 19, 1863. 4. W. F. Denning's fireball of June 7, 1878. 5. A swarm of meteors seen October 6, 1952, by S. N. Grigorieva; the circle indicates the size of the moon. 6. Fireball seen July 27, 1874, by P. Tacchini.

This bright Perseid meteor on August 13-14, 1959, was photographed by George W. Rippen at Des Plaines, Illinois, during an IGY meteor observing session. It traveled up the sky past the stars in Cassiopeia at the right, and was of a yellow color that changed somewhat at the terminal double explosion. Its magnitude was visually estimated as −3.0, and it occurred at 11:23:35 p.m. Central standard time. The stars trailed during the half-hour exposure.



The distribution of 11,073 radar meteor velocities, by D. W. R. McKinley, National Research Council, Canada.

M. Almond, J. G. Davies, and A. C. B. Lovell concluded from radar observations of over 1,000 meteor velocities that the number of hyperbolic meteors must be considerably less than one per cent of the total.

A similar result is evident from the accompanying chart by D. W. R. McKinley, of the velocities of 11,073 meteors recorded by radar in Canada. Very few had relative velocities greater than 72 kilometers per second, and even these few could have originally had elliptical orbits that were changed to hyperbolas by planetary attraction.

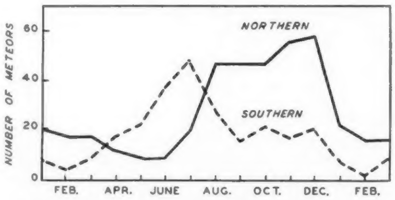
While nearly all meteors are members of the solar system, recent work by British and American astronomers emphasizes the distinction between two kinds: meteors moving in well-defined streams, and the sporadic meteors, whose motions are much more haphazard in direction. Classical theory, on the assumption that the motions of meteors are random, permits determining the relation between the hourly number of meteors and the time of day. It predicts a marked maximum in the rate of sporadic meteors at about the time of sunrise or, more precisely, when the direction of the earth's orbital motion is toward the observer's zenith.

Observations show this effect plainly. There are also differences between the rates counted by Northern and Southern Hemisphere observers, as is shown by the Harvard photographic records. This difference is, however, due to shower meteors rather than randomly moving sporadic ones.

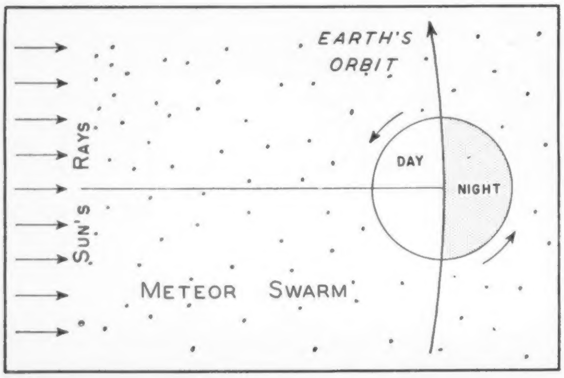
Even at present, careful studies of hourly and annual variations of meteor numbers by visual observers may yield interesting results. Moreover, there is always the possibility that a new, unpredicted shower might appear, or that one known for many centuries may become more intense or less.

The apparent radiants of meteor showers – which may be obtained by prolonging the observed tracks backward on a celestial globe or suitable star chart – have several important properties. They are not geometrical points, as they would be if the meteor paths were strictly parallel straight lines, but are small extended areas. During the course of a night, a radiant undergoes a sizable shift. This is due to zenith attraction (the curvature of meteor paths by the earth's gravitation) and to daily aberration (the change in the observer's relative position because of the earth's rotation). In addition, the location of the radiant among the stars has a slow but uniform shift from one night to the next, because of the earth's orbital motion.

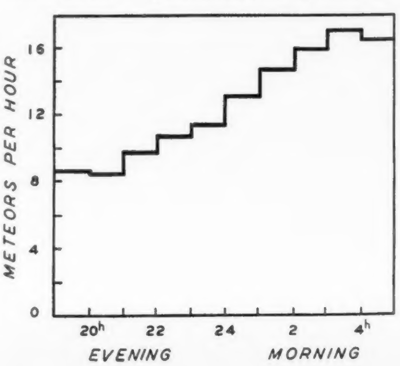
These shifts are charted (facing page) for the Perseid radiant, where the straight line indicates the motion of the radiant on the celestial sphere, after corrections have been applied for zenith attraction and daily aberration. The Perseid radiant travels about three degrees in two days, but that of the Draconids moves only a fraction of a degree during an equal time.



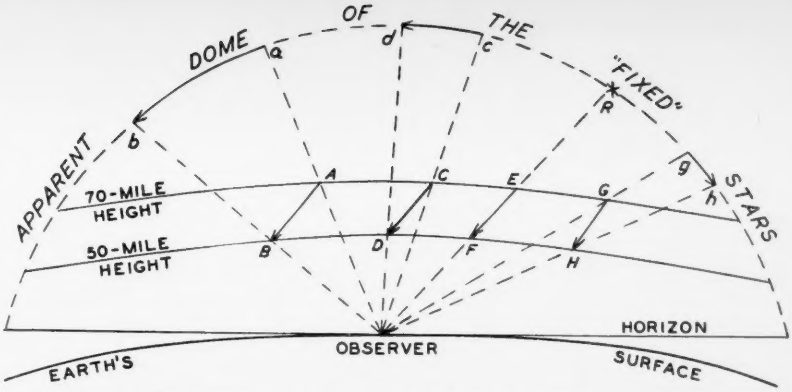
Monthly counts are plotted here for 582 meteors that were photographed by Harvard Observatory telescopes in the Northern and Southern Hemispheres between 1889 and 1936.



At the left the earth is seen moving in its orbit among the meteors in space. Observers are located on the forward-moving side of the globe after midnight, and therefore encounter more sporadic meteors. The chart at the right shows that the average number of meteors observed increases, as expected, until dawn.



The characteristics of the radiants, particularly the spreading of a radiant over an area, demonstrate that meteor swarms are fairly wide toroids, in which the meteors follow slightly different orbits. Whipple and Miss F. W. Wright have shown that the showers with longer durations have more diffuse radiants, and they suggest that as a meteor swarm ages it spreads out over a greater volume of space and the individual meteor orbits become increasingly divergent. Most shower radiants lie near the ecliptic, an indication that the motions of the meteor streams, at least, are not at random, but favor the central plane of the solar system.



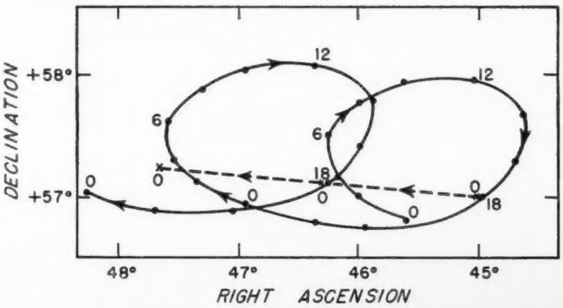
To illustrate how perspective produces the effect of a radiant for shower meteors entering the atmosphere along nearly parallel paths, the simplifying assumption has been made that they have the same heights and true lengths.

Individual sporadic meteors may be considered to have radiant points also. For such an object, the radiant is that point in the sky from which the meteor would be seen to come if it were heading straight for the observer. The radiant of a sporadic meteor can be determined if its track has been plotted and its velocity measured, the zenith attraction and daily aberration corrections being applied just as with shower meteors. A high percentage of all visual meteors appear to be sporadic.

Hawkins' results from radar observations, and those of both Hawkins and J. P. M. Prentice from visual data, show a heavy concentration of radiants near the apex of the earth's orbital motion (the point on the sky toward which the earth is moving at any moment). This is expected from the sweeping action of the earth, as we have already noted. But there are two other concentrations of radiants, one in the direction of the sun, the other 180 degrees from it, although the former cannot be detected by visual observations since few meteors are seen during the day. When these results are corrected for the earth's motion relative to the sun, there is a marked preponderance of meteors overtaking the earth, about 30 times as many as there are colliding with it head on. The visual observations for meteors of low inclination to the ecliptic confirm this result, giving a 50-to-one ratio for inclinations less than 50 degrees. Evidently, the assumption of randomness of meteor motions is a very poor approximation to the truth – most meteors following the ecliptic and having direct motions, in the same west-to-east manner around the sun as the earth and the other planets in the solar system.

Whipple and L. G. Jacchia have further found "that a distinction can be drawn between directly moving and retrograde orbits. The direct orbits tend to have short periods, high eccentricities, and low inclinations, resembling very closely the orbits of short-period comets. On the other hand, retrograde orbits have a longer period and a more uniform distribution of inclinations, resembling the distribution of long-period comets."

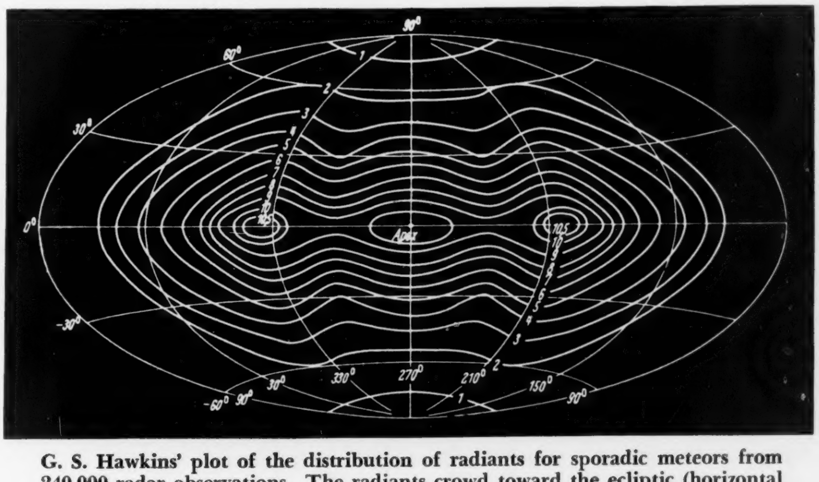
Thus, the majority of sporadic meteors, like those belonging to showers, are of cometary origin. Only the brightest meteors, fireballs, and meteorites are physically the same kind of body as the minor planets. Among the faintest telescopic meteors there *may* be an increasing number of interstellar particles. But no velocity determinations have as yet been made for the faintest meteors observable through a large telescope.



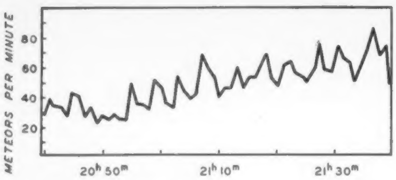
Six-hourly positions of the Perseid radiant are labeled here by Astapovich, for two successive days. The straight line indicates the motion of the radiant on the celestial sphere, after corrections for zenith attraction and the daily aberration have been applied.

One of the most mysterious problems, which I believe can best be solved by the combined efforts of several visual observers, concerns the nonuniform occurrence of meteors with time. As long ago as 1902, V. K. Ceraski remarked that Perseid meteors tend to appear in groups of two or three, first in one constellation, then in another. This was also noted by D. O. Sviatsky in 1902 and F. Quénisset in 1910. The latter remarked, "Groups of two, three, and four meteors follow one another within intervals of a few seconds, after which there is usually a quiescent period."

G. A. Shajn, also in 1910, wrote: "After a fairly long interval of time, there appeared almost simultaneously groups of several meteors." At about the same period, I also had the impression that the meteors of the Perseid shower tended to come in groups of several in quick succession. In 1926, A. F. Subbotin plotted the numbers of Perseid meteors as a function of time and found a distribution which, though nonperiodic, could not be ex-

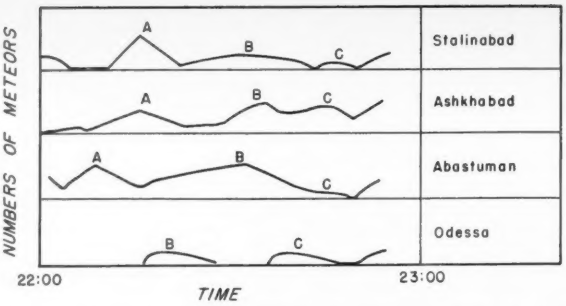


G. S. Hawkins' plot of the distribution of radiants for sporadic meteors from 240,000 radar observations. The radiants crowd toward the ecliptic (horizontal axis). Also, they concentrate toward the apex of the earth's motion and to two points in the sky 90 degrees away. From the "Handbuch der Physik."



Left: Fluctuations in the rates of Perseid meteors are charted from counts by A. F. Subbotin in 1926.

Right: Evidence for large clusters of meteors is provided by correlations between simultaneous counts at four Soviet stations along a 2,500-mile line, according to Astapovich.



plained in terms of normal statistical fluctuations. In 1934 Miss D. Hoffleit found that even the sporadic meteors tend to appear in clusters. A similar result was obtained in 1951 by A. S. Agadzhanova.

Astapovich feels that meteor showers consist of clusters or clouds, some having only a few meteors separated from one another by a few hundred kilometers. These are seen at a single site within a few seconds. Other clusters contain hundreds of thousands of particles occupying a volume thousands of kilometers in diameter. These can be observed at widely separated points on the earth, 1,000 kilometers or more apart.

The sketch represents a small cluster and a large cloud. Note also the graph of some of the actual, simultaneous counts of Perseid meteors made at four stations in 1950, 1951, and 1953. Although Astapovich shows only this one sample, presumably similar results were obtained at other times. Other such work is desirable, since the identifications of clouds **A**, **B**, and **C**, as well as the empty spaces between them, are perhaps not too convincing.

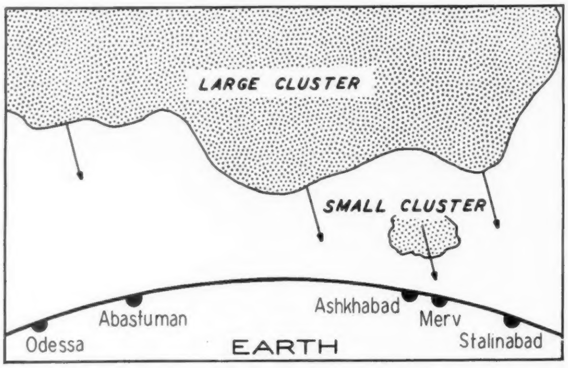
Average distances between neighboring particles of a dense shower are about 30 to 40 kilometers, compared to as much as a million kilometers in a very diffuse one. As the average mass of each particle is a small fraction of a gram, the mutual gravitational attraction between particles is practically zero. It is, therefore, difficult to account for the existence of any clusters of meteors within a large swarm.

The gravitational perturbations of the orbits of individual meteor swarm particles by Jupiter and other planets should gradually spread the stream out in cross section, nearly along the ecliptic. S. E. Hamid has found that the presently observed scatter of Perseid radiants is consistent with the hypothesis that the stream was dispersed from Comet 1862 III about 250 revolutions ago, when its orbit crossed Jupiter's. And M. Plavec concluded in 1950 that the Geminid stream was being so rapidly scattered by perturbations that the shower may last only about a hundred years.

According to Whipple and others, collisions between particles, corpuscular radiation from the sun, and solar heating all contribute to the dispersal of initially very compact streams. Some of these effects act more powerfully upon small than large particles. This may help to explain why Hawkins and Miss Almond found that "the percentage of bright meteors increases at the maximum of the Perseids and Geminids and that these streams contain a 'core' of large, undisturbed particles." Yet all of these effects would be expected to produce a statistically smooth distribution of meteors within a swarm of increasing cross section.

If future observations confirm the existence of clusters within the large swarms, we may be forced to think of processes like the splitting of comets into several parts. Biela's comet, which had a period of nearly seven years, was observed as a single object in 1772, 1806, 1826, and 1832. But in 1846, while under observation, it first became pear-shaped, and later divided into two comets that traveled along side by side 200,000 kilometers apart. In 1852 the twin comets were again seen, but the separation was 10 times greater. They have never been observed since, except as Andromedid meteors.

The breakup of the nucleus of Comet 1882 II is shown in drawings by A. A. Common. The top small-scale view was by day on September 17, 1882, with a 6-inch refractor. His other sketches were made with his 36-inch reflector. In the middle one, the nucleus had become an elongated interrupted bar (October 31st). Finally, on January 27, 1883, it was fivefold.



Right: Some meteor phenomena can be explained, Astapovich believes, by the influx of large and small clouds of meteors, one of the latter being shown here over observing stations at Ashkhabad and Merv.

Taylor's comet, 1916 I, also broke into two parts. The brilliant comet 1882 II, which passed through the solar corona, separated into four parts whose periods are 664, 769, 875, and 959 years, according to H. Kreutz. Though none of these have had time to return to perihelion, of course, it has been suggested by I. G. Parker that five other comets, with orbits resembling that of this brilliant one, may be older splinters.

It is tempting to suppose that explosive forces within the icy conglomerates of comet nuclei that produced the breakups of comets Biela, Taylor, and 1882 II, may be acting in all comets as they approach the sun. And it may be that we do not see the actual breaking off of fragments at large distances from the earth, yet these might conceivably produce the clustering of meteors.

Instruments at the Leiden Southern Station

"LIGHT COLLECTOR" is a better descriptive term than telescope for the 36-inch reflector pictured on the front cover. Designed especially for photoelectric photometry of stars in five colors simultaneously, it is intended to give a sharp image only on the optical axis, rather than to furnish an extended working field.

Erected in South Africa in 1957, it is one of the principal instruments at the new southern station of the Netherlands' Leiden Observatory, situated some 20 miles west of Pretoria near the artificial lake created by the Hartebeespoort Dam. There it enjoys the favorable observing climate of the high veld, yet is not too remote from cities.

The new station supersedes an earlier observing site at Johannesburg, in use by Leiden astronomers for over 30 years. There the main instrument was a 16-inch double refractor, shown here as re-erected at Hartebeespoortdam. It has been used mainly for variable star studies, both photographic and photoelectric. Also transferred from Johannesburg is the historic Franklin-Adams camera, a wide-field 10-inch refractor, well known for charting the sky and for variable star surveys.

The 36-inch is a fork-mounted Cassegrainian, with a spherical primary mirror and a highly figured secondary. The fact that the primary is not a paraboloid is no handicap, since only one star, at the center of the field, is observed at a time.

With older instruments, observing the brightness of a faint star with a photoelectric photometer has been a somewhat tedious operation. The star first has to be identified among its neighbors, usually with the aid of a marked photograph, this often taking more time than the measurement itself.

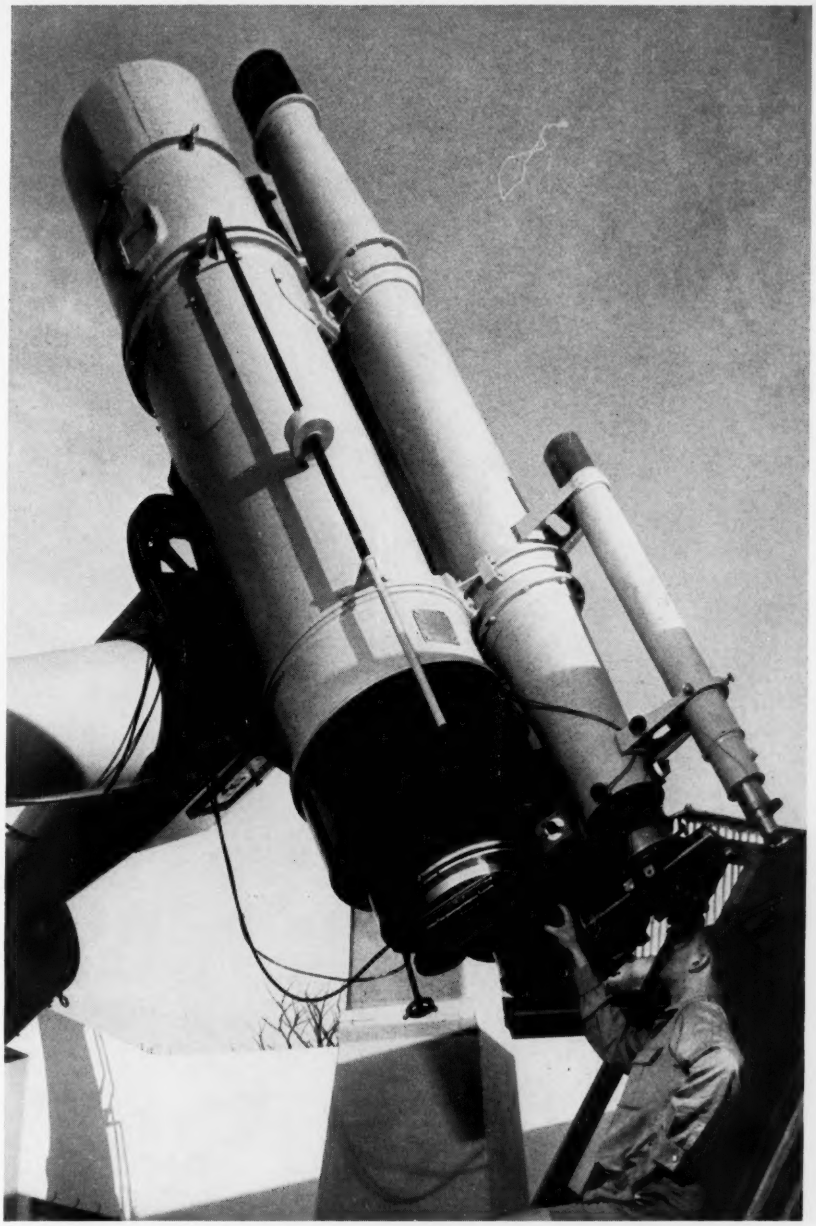
This difficulty is avoided by the very precise construction of the new mounting, permitting use of an automatic steering system for quick and exact pointing. The observer sits at the control panel, sets the right ascension and declination of the star on indicators, and electric motors swing the telescope to the desired direction, to within 10 seconds of arc.

At this stage the light of the star is caught by a photocell, which determines any small deviation in the setting and effects an improved pointing to inside one second of arc. Immediately after this, the starlight is passed into the measuring photometers, the brightness in five colors being automatically registered. While this observation is going on, the observer presets the co-ordinates of the next star in his list; then he has only to operate one switch to turn the telescope to that star and repeat the observing cycle.

This automation greatly increases the speed and ease with which observations can be made. Instead of one star requiring as much as 15 minutes, now only a few minutes are needed, a gain of great importance in carrying out photoelectric programs involving thousands of stars. No wonder that the light-collector type of instrument is coming into use at many observatories.

The 36-inch carries a "spectrograph" permanently mounted at the Cassegrainian focus. This divides the starlight into five well-defined spectral regions: ultraviolet, blue, green-yellow, red, and infrared. These five colors are received by five photomultipliers, so that each range of wave lengths is measured simultaneously.

The primary mirror and secondary were made at Yerkes Observatory, while the mounting was constructed by the Dutch firm of Rademakers, in Rotterdam.



J. Wolterbeek looks through the 8-inch guiding telescope of the famous Rockefeller twin photographic refractor. The mounting is by Grubb Parsons, and is carried on two piers. The two 16-inch objectives are by Zeiss, but only one of the main tubes is readily visible in this Leiden Observatory photograph.

Abbe Lacaille's List of Clusters and Nebulae

OWEN GINGERICH
Harvard College Observatory

Nicolas Louis de Lacaille (1713-62) was among the leading French astronomers of his day. During his expedition to South Africa, he compiled the pioneer catalogue of southern star clusters republished here in modern form. From an engraving courtesy of Paris Observatory.

IN 1755, 16 years before the first installment of Messier's catalogue of nebulae and clusters was printed in the *Mémoires* of the French Academy, a rather similar tabulation had appeared in the same publication. This list of 42 southern nebulae was abstracted by Abbé Nicolas Louis de Lacaille (1713-62) from his catalogue of about 10,000 stars compiled during an expedition to the Cape of Good Hope in South Africa.

Later, in three volumes of the French almanac *Connaissance des Temps* (1783, 1784, and 1787), the Lacaille list was reprinted along with the Messier catalogue and its extensions. Today the Messier numbers are commonly used for those 103 objects, while Lacaille's have slowly dropped into oblivion. The latter's collection did not lack spectacular objects, for among its entries are the globular clusters Omega Centauri and 47 Tucanae, the diffuse nebulae Eta Carinae and 30 Doradus, and the cluster Kappa Crucis.

Why, then, has not the Lacaille compilation achieved as much fame among southern observers as its northern counterpart? First, his notation has proved unfortunately cumbersome. Unlike the Messier listing, which grew over more than a decade and whose objects run numbered in order of observation, the Lacaille catalogue was compiled in less than a year – from August, 1751, to July, 1752. Consequently, it was possible not only to arrange the objects in order of right ascension, but to list them in three categories: I, nebulae without stars; II, nebulous clusters; III, stars accompanied by nebulosity. The five objects mentioned above thus have the rather awkward designations Lac I-5, Lac I-1, Lac III-5/6, Lac I-2, and Lac II-12, respectively. The Arabic numbers refer to their order in his three classes.

Further inspection reveals that Lacaille's collection is not really as much of a southern counterpart to Messier's as might be expected. Both astronomers prepared their lists as incidental parts of other, very different investigations. Messier was concerned with comets, and for his sweeps of the sky he used telescopes with apertures of about three inches. He considered his catalogue of nebulae a list of "nuisances" for comet hunters to avoid.

Working about two decades earlier, Lacaille had singlehandedly revived positional astronomy in France, and for recording star positions he employed much smaller telescopes. Thus, there is a considerable disparity between the two men's lists in regard to limiting magnitudes and resolution. At least eight of Lacaille's 42 objects are mere asterisms, which Messier probably would have rejected (although his catalogue does contain two such entries, M40 and M71). And while Messier listed many faint galaxies, Lacaille included but one, M83 (Lac I-6).

Lacaille's life and work seem to pivot about the South African expedition which produced, as a by-product, this first systematic catalogue of nebulous objects. He originally undertook theological studies, but later devoted himself exclusively to astronomy. In his investigations, he brilliantly coupled theoretical with observational work.

The French astronomer was concerned with the orbital elements of comets and planets, especially of the earth. This led to observations of fundamental positions of the stars, to a study of atmospheric refraction, and ultimately to determining the lunar and solar parallaxes. His student Lalande said of him that during his comparatively short life Lacaille had made more observations and calculations than all the astronomers of his time put together.

His trip to the Southern Hemisphere in 1750 was to determine more accurately the distances to the sun and moon. Observations of the moon, Mars, and Venus were made from both hemispheres simultaneously, and the resulting triangulation

FACING PICTURE: The nebula surrounding the variable star Eta Carinae, photographed in red light with the 60-inch reflector at the Boyden station in South Africa. Lacaille observed this object in 1752. While an observer should be south of the equator for a good view of this remarkable nebulosity, which is at declination −59°, amateurs in Florida and the southernmost part of Texas may catch a glimpse of it whenever it reaches its greatest altitude. Harvard Observatory photograph.

allowed him to establish the distance to the moon as 250,000 miles and to the sun as 81,000,000 miles.

While at the Cape of Good Hope, Lacaille surveyed the first South African arc of the meridian, and observed the positions of 9,766 stars in the southern sky. He devised an interesting technique for rapidly observing this vast number of stars. His ½-inch f/50 telescope of 8 power was rigidly attached to a mural quadrant, and a rhomboidal diaphragm was placed in the field of the instrument. As the stars in a 2.7-degree zone drifted through his field in their daily motion, Lacaille recorded the times when they entered and left the rhombus. The average of the two sidereal times for a star gave its right ascension, while the difference of the times was a function of its declination.

Lacaille reduced the positions of 1,942 of these stars for a preliminary catalogue, but mapped all 9,766 into a celestial atlas. In this work he completed the naming of southern constellations by charting Sculptor, Fornax, Horologium, Reticulum Rhomboidalis, Caelum, Pictor, Pyxis, Antlia, Octans, Circinus, Norma, Telescopium, Microscopium, and Mons Mensae. Among these, readers will recognize the names of several of Lacaille's instruments.

One of the first results of the expedition, reported to the Academy of Sciences after Lacaille's return in 1754, was the catalogue of nebulae that had been observed during his zone surveys. He wrote:

"The so-called nebulous stars offer to the eyes of the observers a spectacle so varied that their exact and detailed description can occupy astronomers for a long time and give rise to a great number of curious reflections on the part of philosophers. As singular as those nebulae are which can be seen from Europe, those which lie in the vicinity of the south pole concede to them nothing, either in number or appearance. I am sketching out this description and list to serve as a guide for those with the equipment and leisure to study them with larger telescopes. I would have greatly desired to present something more detailed and instructive in this article, but with ordinary refractors of 15 to 18 inches [in length] such as I had at the Cape of Good Hope, I had neither adequate nor convenient enough instruments for this kind of research. Those who do take the trouble to see what has occupied me during my foreign sojourn will see well enough that I did not have time to make that sort of observation."

After mentioning his division of nebulae into three categories, Lacaille added, "I have found a great number of the three types of nebulosities in the southern part of the sky, but I do not flatter myself to think that I have noticed them all, especially those of the first and third types, because they can only be perceived after twilight and in the absence of the moon. However, I do hope that the list is passably complete in regard to the most remarkable of the three types."

Readers may find more information on Lacaille's life and work at the Cape of Good Hope in D. S. Evans' article "La Caille: 10,000 Stars in Two Years," which appeared in the British periodical *Discovery*, October, 1951, page 315.

LACAILLE'S CLASS I: NEBULAE

Lac.	*NGC*	*R.A.*	*Dec.*	*Type*	*Const.*	*Mag.*	*Diam.*	*Name*
I		h m (1950)	° ′				′	
1	104	00 21.9	−72 21	Gb	Tuc	3.0	23	47 Tuc
2	2070	05 39.9	−69 04	Di	Dor	—	20 × 20	30 Dor
3	2477	06 50.5	−38 25	Cl	Pup	—	25	—
4	4833	12 56.0	−70 36	Gb	Mus	6.8	5	—
5	5139	13 23.8	−47 03	Gb	Cen	3.0	23	ω Cen
6	5236	13 34.3	−29 37	Sp	Hya	8.0	10 × 8	M83
7	5281	13 43.1	−62 39	Cl	Cen	—	3	—
8	6124	16 22.2	−40 35	Cl	Sco	—	25	—
9	6121	16 20.6	−26 24	Gb	Sco	5.2	14	M4
10	6242	16 52.2	−39 25	Cl	Sco	—	10	—
11	6637	18 28.1	−32 23	Gb	Sgr	7.5	3	M69
12	6656	18 33.3	−23 58	Gb	Sgr	3.6	17	M22
13	6777	19 21.4	−71 39	—	Pav	—	—	—
14	6809	19 36.9	−31 03	Gb	Sgr	4.4	10	M55

Remarks: 11, listed in NGC erroneously as 6634. 13, NGC 6777 is nonexistent; the nearest object answering Lacaille's description (similar to M22) is NGC 6752, more than 10 degrees away in a different declination zone.

LACAILLE'S CLASS II: NEBULOUS CLUSTERS

Lac.	*NGC*	*R.A.*	*Dec.*	*Type*	*Const.*	*Mag.*	*Diam.*	*Name*
II		h m (1950)	° ′				′	
1	—	04 02.1	−44 35	—	Hor	—	—	—
2	—	07 24.4	−34 02	—	Pup	—	—	—
3	2516	07 59.7	−60 44	Cl	Car	—	60	—
4	2546	08 09.8	−37 14	Cl	Pup	—	30	—
5	I 2391	08 41.2	−52 45	Cl	Vel	—	20	θ Vel
6	—	08 44.8	−42 23	—	Vel	—	—	—
7	3228	10 19.7	−51 28	Cl	Vel	—	30	—
8	—	10 33.9	−57 56	—	Car	—	—	—
9	I 2602	10 41.0	−64 08	Cl	Car	—	70	—
10	3532	11 03.4	−58 24	Cl	Car	—	60	—
11	—	11 20.7	−58 03	—	Cen	—	—	—
12	4755	12 50.6	−60 05	Cl	Cru	—	10	κ Cru
13	6231	16 50.7	−41 43	Cl	Sco	—	15	—
14	6475	17 50.7	−34 48	Cl	Sco	—	60	M7

Remarks: 1, a loose group of six to eight stars. 2, described by Lacaille as a "group of eight stars of 6-7 magnitude which to the naked eye forms a nebulosity in the sky." 6, Lacaille: "seven or eight stars slightly separated." 8, Lacaille: "four small stars in a diamond"; near IC 2599, a nebulous star. 11, Lacaille: "seven or eight small stars close together in a straight line."

LACAILLE'S CLASS III: STARS ACCOMPANIED BY NEBULOSITY

Lac.	*NGC*	*R.A.*	*Dec.*	*Type*	*Const.*	*Mag.*	*Diam.*	*Name*
III		h m (1950)	° ′				′	
1	—	05 02.0	−49 33	—	Pic	—	—	—
2	2547	08 08.9	−49 07	Cl	Vel	—	15	—
3	—	08 40.6	−47 53	Cl	Vel	—	20	—
4	I 2488	09 25.7	−56 45	Cl	Vel	—	20	—
5} 6}	3372	10 43.1	−59 25	Di	Car	—	80 × 85	η Car
7	3766	11 34.2	−61 19	Cl	Cen	—	10	—
8	5662	14 31.5	−56 21	Cl	Cen	—	8	—
9	—	15 18.6	−59 01	—	Cir	—	—	—
10	6025	15 59.4	−60 22	Cl	TrA	—	10	—
11	6397	17 36.8	−53 39	Gb	Ara	4.7	19	—
12	6405	17 36.8	−32 11	Cl	Sco	5.3	25	M6
13	6523	18 01.6	−24 20	Di	Sgr	6.8	35 × 60	M8
14	—	21 27.7	−58 48	—	Ind	—	—	—

Remarks: 1, loose group of about six stars preceding η_2 Pic. 3, around 5th-magnitude star GC 11988. 5, 6, parts of η Car recorded in two different zones. 9, triangle of 8th-magnitude stars north of γ Cir. 14, line of faint stars.

KEY TO LISTING

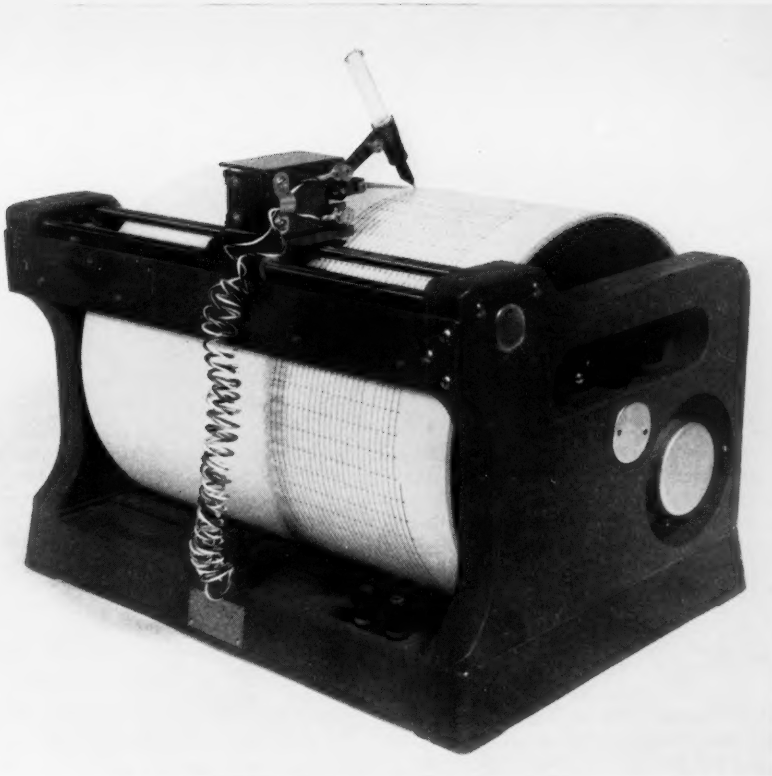
The positions are for epoch 1950. When an NGC (or IC) number is given, the position is taken from the Skalnate Pleso *Atlas Catalogue*. Photographic magnitudes and diameters are from the same source, except for Lac II-4 and Lac III-3, which have diameters measured from the Franklin-Adams charts. When no NGC (or IC) number is given, the position has been precessed from the reduction of Lacaille's star catalogue made during the 1840's in Edinburgh by Thomas Henderson. Eight of the objects also have Messier numbers.

Cl is for open or galactic cluster; *Gb*, for globular cluster; *Di*, for diffuse nebula; and *Sp*, for spiral galaxy.

A New Astronomical Chronograph

William Mussetter

Army Map Service, Corps of Engineers

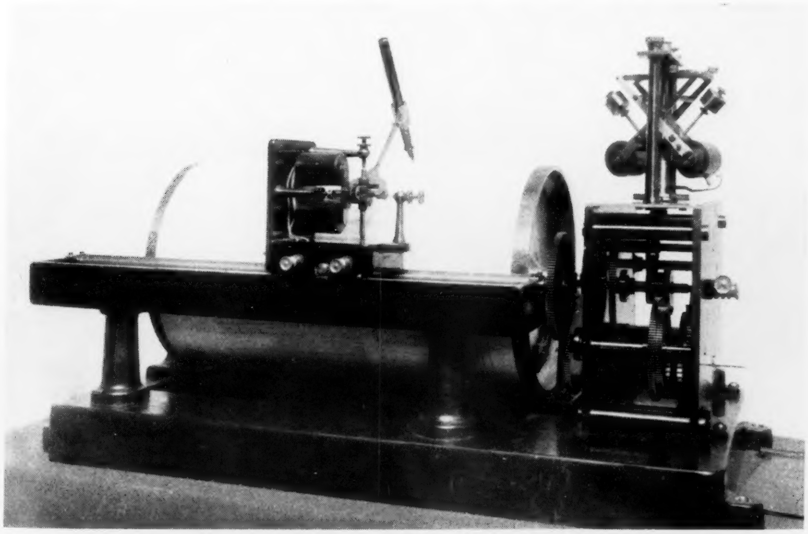


For accurate timings of observations by field expeditions of the department of geodesy, Army Map Service, this compact and rugged astronomical chronograph was designed by the author. The driving mechanism and clutch are inside the drum, which rotates once a minute. Army Map Service photograph.

PRECISE star observations for latitude, longitude, and azimuth are basic to constructing all maps of the earth's surface. The times at which telescope pointings are made on the stars must be known, because of their apparent motions in the heavens.

Whereas less precise observations may need only an approximate time read from a watch fairly well set to local time, work of a higher order imposes stricter limits. The recording of the times of star transits for observing longitudes of first-order accuracy permits an error of but a few thousandths of a second. Such records are made graphically by "event-marking" instruments. A chronograph is a device of this type especially designed for the purpose.

Invented by W. C. Bond, first director of Harvard Observatory, pen-recording chronographs have been employed by astronomers for more than 100 years. However, the commercial models are generally designed for permanent mounting, and have several disadvantages for field use by the Army Map Service in remote parts of the world. Not only are such instruments excessively large and heavy, but their internal movements are vulnerable to grit and moisture. Thus, for our worldwide program of astrometric observations, we decided to construct a compact, rugged, light-weight instrument that would overcome these faults and make an easily read record of satisfactory scale.



This old-style chronograph, of a type still widely used, was constructed about 1880. The apparatus weighs 87 pounds, needs a 25-pound driving weight, and is much bulkier than the new model shown above, although both drums have the same diameter. U. S. Coast and Geodetic Survey photograph.

Pen-recording chronographs may be of the drum type or the tape type. The first employs a rotating cylinder, or drum, around which is wrapped a sheet of paper. The record is made by a pen or stylus held against the moving paper. In the other type, a narrow paper tape is drawn under the pen at a constant speed.

In the drum chronograph, the pen is mounted on a carriage that is slowly driven by a screw in a direction parallel to the axis of the drum. Therefore, the line drawn by the pen takes the form of a helix, and many yards of record may be made on an ordinary sheet of paper. On the other hand, a tape instrument requires one yard of tape for one yard of record, thus making it inconvenient to mark, reel, scale, and store the continuous record. To prevent excessive lengths of tape, it is customary to start the chronograph for each comparison with a radio time signal or star transit, and to stop it as soon as finished. The independent records then obtained must be identified carefully.

The pen itself is carried on the end

This portion of an original field record made with the author's chronograph is from the files of the Army Map Service's department of geodesy, Americas division. It shows the actual transit observations of stars in Cygnus and Pegasus. Time runs to the right, and each successive line is a minute later than the one above it; space permits reproduction of only those seconds in each minute from 38 to 14, the chronograph making ticks to mark these at two-second intervals. The top line is for 21:30 local chronometer time, the lowest shown for 22:03, but the entire sheet of this record runs to 22:27 and includes more stars in Pegasus and Lacerta. In the left center, one of the time signals from WWV is marked 21:20. The star transits are observed by means of a moving wire in the field of view, which the observer keeps bisecting the star as it crosses the field. This moving wire makes electrical contacts that in turn impress ticks (checked with small ink marks) on the chronograph record. Measurement of the positions of these ticks permits calculation of the precise time at which the star crossed the local meridian. The beginning and ends of the records for 16 Pegasi and 20 Pegasi are included. The scale of the reproduction is half that of the original record. Courtesy U. S. Army Map Service.

of an arm attached to the armature of a magnet. Whenever the magnet is energized by an electric current, the pen is jerked sidewise, producing a break or tick in the drawn line. Two such ticks, produced by any electrical signal, will be separated by a distance depending on the interval of time between them and the rate of rotation of the drum.

A very accurate clock — a chronometer — is customarily employed with a chronograph. A mechanism built into the works of the chronometer alternately makes and breaks an electrical circuit, usually at one- or two-second intervals, thereby providing the time base for the record. Any other signal, such as a radio time signal pulse, or one triggered by the observer at the instant a star crosses the meridian, will make a tick between two of the base marks. Its exact position between these, and hence its time interval from one or the other, may then be scaled off.

The accuracy of this measurement depends only on the uniformity of the drum's rotation, not upon its absolute speed. As the interval between the time-base ticks is only one or two seconds, a reasonably smooth motion will produce a record with negligible error. This speed is regulated by some form of governor, depending on the type of power supply. The simplest, of course, is electric drive by a synchronous motor operating on alternating current. The governor, in this case, is the frequency regulation of the power supply.

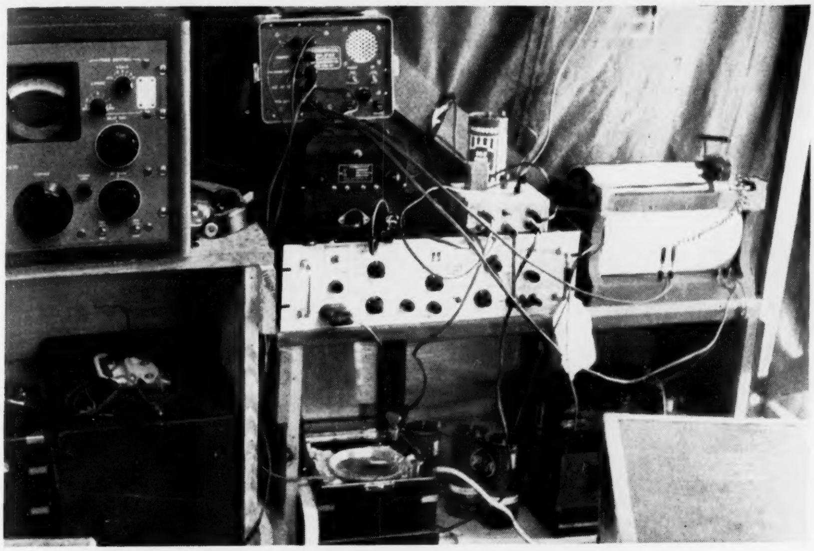
But carefully regulated alternating current is seldom available in the field. Hence, in the past, drum-type chronographs have been spring- or weight-driven with centrifugal or combined centrifugal-friction governors. Although these consume considerable power and require frequent adjustment under field conditions, they have been fairly satisfactory.

Tape chronographs are usually spring-driven and controlled by vibrating-reed governors. Other possibilities include rheostat- or hysteresis-controlled direct-current motors operating on batteries, synchronous motors using the amplified output of a constant-frequency oscillator, or special direct-current motors regulated by intermittent brush contacts.

The scale depends on the rate at which the paper is drawn under the pen, about 10 millimeters per second for almost all drum chronographs. In order that successive minutes of the record will appear as parallel lines across the paper, the drum usually revolves at one revolution per minute. Therefore, to secure the scale above, the drum diameter is $7\frac{1}{2}$ inches, which largely determines the over-all size of the instrument. The dimensions of tape chronographs, on the other hand, are substantially independent of the paper speed, and they frequently have optional scales greatly exceeding those of drums.

Our field users of chronographs unanimously preferred the drum type, particularly for its economy of scaling, which overruled any disadvantage of larger size. Longitude observations are broken down into a series of star transits requiring an average time of 35 minutes, although varying greatly. A complete observation and comparison with radio time signals are desirable on a single sheet, but the paper may be changed during any interval between star transits with slight in-

View at Camp Century, Greenland, in latitude 76° 06′ north. The theodolite used by the author (see the picture on the facing page) was mounted in the sheltered observation pit to the left of the trailer living quarters. Photograph by J. K. Mears.



Some of the equipment needed for chronographic timing of star observations, inside a tent at the geodetic field station "Clyde 39" on Baffin Island, Canada. On the floor (center) is a chronometer whose beats are recorded on the chronograph, right. The latter is also connected with a short-wave radio receiver to obtain WWV time signals. Underneath the chronograph is its power supply, a 12-volt automobile battery. Photograph by J. K. Mears.

convenience. It was therefore decided to limit the record to about one hour, giving 128 feet of line at 10 millimeters per second, the drum running continuously. Standard-width paper could be used, as the drum is only 10 inches long, after allowing for paper fasteners and a spacing of the lines on the record sufficiently open for easy reading.

A recently developed direct-current motor weighing only $8\frac{1}{2}$ ounces was adopted to drive the drum, the constant-speed mechanism employing a jeweled balance wheel and hairspring. The power supply is interrupted 900 times a minute by a commutator brush lifted by a cam. Should the motor be lagging, the restoration of current is almost instantaneous; if it is overrunning, there is a delay. Gears within the motor give an output of 10 revolutions per minute, which is reduced to a drum speed of one r.p.m. by a large gear of precise manufacture.

The power is provided by a standard 12-volt automotive battery, which must be available for other purposes, and can also be recharged in the vehicle during trips between observing stations.

Compactness was achieved by a number of design innovations, including placing the drive mechanism within the overhang of the drum at one end provided by recessing the head three inches. Cored recesses were used for the protection of the clutch lever, motor switch, and chain for driving the pen translation screw, as well as to provide handholds. The pen is located in an accessible position where it writes directly on top of the drum. As finally designed, the chronograph is about nine inches high, nine inches wide, and 12 inches long.

As these instruments are frequently mishandled in shipment, and may meet with accidents in the field, particular attention was given to building a chronograph that would be rugged and resistant to misalignments that would impair its action. The drum and its axis can take a 200-pound load suddenly applied in the most unfavorable position. The drum will withstand a dishing stress of 250 pounds, and the rigid standards carry a reinforcing angle to protect the screw; this also stops any deflection of the pen carriage guides before their elastic limit is reached.

The basic instrument parts are hardened aluminum alloys, except the polyethylene-fiberglass drum shell, which is four pounds lighter than the customary brass drum. The pen carriage is mounted on nylon bushings running on a stainless-steel rod, and the drive screw is anodized aluminum alloy with a special thread, the land of which is narrower than the groove. The thread is left-handed so as to produce a normal record reading from left to right. This is an improvement over earlier chronographs, which appear to have been designed for the Arabic trade! The complete instrument weighs slightly under 12 pounds. In its box, the total weight is 20 pounds, while the old models weighed 120.

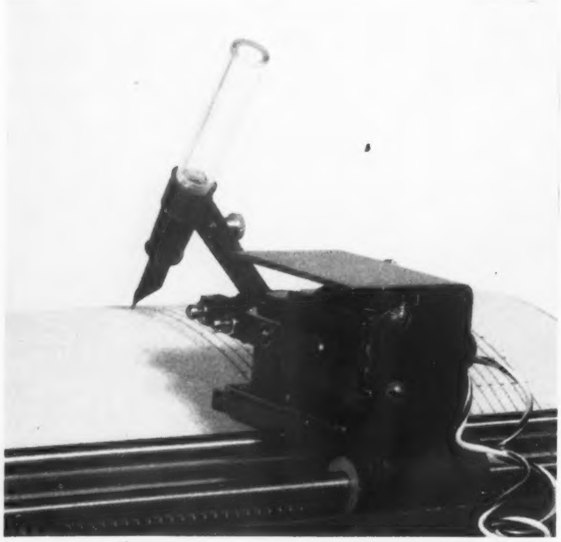
The only controls on the chronograph are the clutch lever and the motor switch, both located in a recess in the right-hand standard; they can be operated by one finger. The pen is returned to its starting point by lifting the carriage to free its driving lug from the screw, and sliding it to the right. This is ordinarily done only when the paper is changed.

The pen mechanism uses standard commercial relay magnets, interchangeable for different voltages. Two magnets, of six volts for battery power, and 5,000-ohm impedance for amplifier plate current, are presently provided. The armature yoke runs in a groove in a post, so that any blow will be absorbed there rather than transmitted to the hinge of the pen. The amplitude of the pen stroke is adjustable, and ordinarily is about 1/16 inch. The pen can move freely in the vertical plane but is held rigid in the horizontal.

There are a number of possible ways for inscribing the record. These include an ordinary fountain pen, electrical methods such as the hot stylus and high-tension discharges that punch holes in the sheet, wax-coated paper, pressure-sensitive paper,

The author is observing Polaris with a Wild T-4 theodolite at Camp Century on the Greenland icecap, in August, 1959. Observation times were recorded with a new chronograph of the type described in this article. The theodolite has a 62-mm. f/8 telescope, 65 power, with the eyepiece at one end of the hollow horizontal axis. Finely divided glass circles enable vertical angles to be measured to 0.2 second of arc, horizontal angles to 0.1 second. Photograph by J. K. Mears.

abrasive coatings, and photographic processes. All of these present certain problems in the field. The fountain pen has been preferred in the past because of its simplicity and availability. However, ink is subject to freezing and is affected by desert dust, and the paper may soften in humid climates. Improvements in wax-coated and pressure-sensitive papers give promise that these methods may eventually supersede the fountain pen. Hard wax surfaces over colored-paper bases are now producing very sharp and durable records that can easily be reproduced.



A detail view of the new chronograph shows the pen and its carriage. The wires carry pulses to a small electromagnet which causes the pen to deflect, making tick marks as shown in the record on page 210. The pen carriage is slowly shifted by the screw (part of which can be seen under the stainless-steel rods supporting the unit). Thus the line traced on the turning paper-covered drum is a spiral. Army Map Service picture.

Six of the new chronographs were built about two years ago by the model shop of the Engineer Research and Development Laboratories, Ft. Belvoir, Virginia. The detailed designs and specifications were made in the department of geodesy, Army Map Service. Since then, 11 additional chronographs of the new design have been built for the Coast and Geodetic Survey and the Air Force by commercial instrument makers.

These chronographs have now seen considerable service and have performed satisfactorily in such varied climates as those of Libya, Ethiopia, and the Greenland icecap. Because of their sturdiness and light weight, the instruments have proven convenient for use on second-order astronomic position and azimuth observations that have heretofore been limited to eye and ear recording. Chronographic recording is expected to improve the accuracy of the observations and to eliminate blunders.

NSF GRANTS FOR OBSERVATORY DEVELOPMENT PROJECTS

The National Science Foundation is entertaining proposals for the modernization, refurbishment, and construction of research laboratory and observatory facilities. The program requires at least 50-per-cent participation by the institution concerned, with funds derived from nonfederal sources. It includes laboratory fixtures and furnishings but excludes apparatus and telescopic or similar equipment.

For the present, the grants are restricted to those university departments that have current programs of doctoral study, but will not be made for facilities to be used primarily for instructional purposes. March 1st is the deadline for the receipt of proposals to be reviewed during the late spring and early summer of this year.

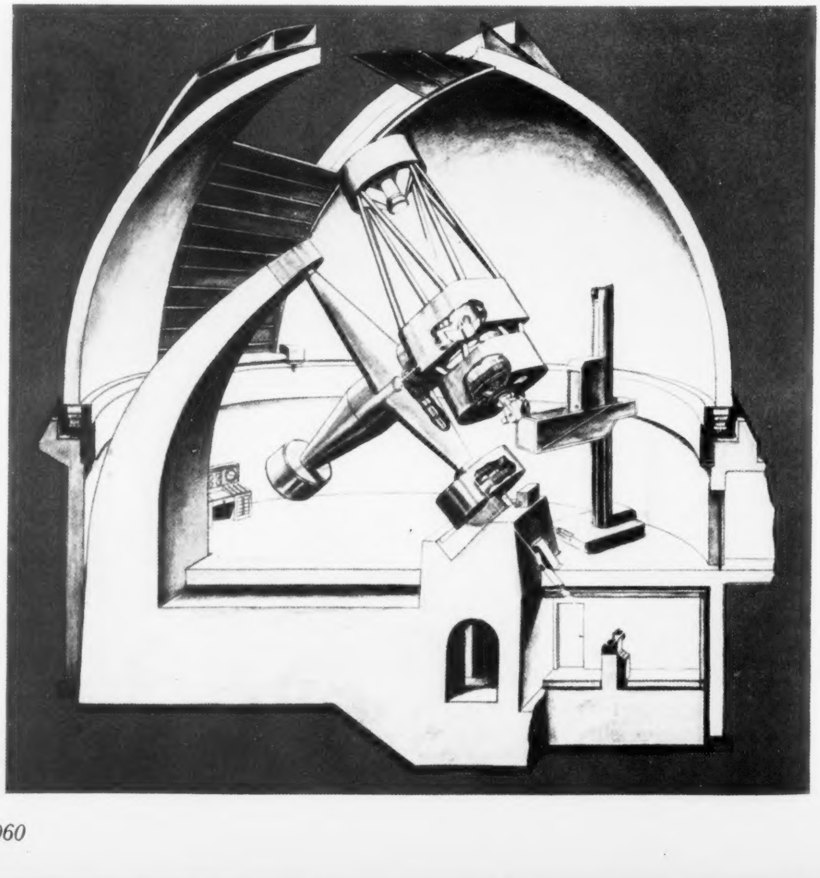
Information concerning the grants and instructions for submitting proposals may be obtained from Division of Mathematical, Physical, and Engineering Sciences, National Science Foundation, Washington 25, D. C.

NEW GERMAN OBSERVATORY

Near Jena, East Germany, a new observatory for the German Academy of Sciences will have a 79-inch (2-meter) reflector, now under construction at the Carl Zeiss Works. This telescope, whose primary mirror is f/2 and spherical, can be operated in three different forms. One is as an f/3 Schmidt camera, its correcting plate being 53 inches in diameter.

When the latter is replaced by a hyperboloidal convex secondary mirror, the telescope becomes a Cassegrainian with an equivalent focal length of 66 feet. The light beam is diverted by a plane mirror through the hollow declination axle to the Cassegrainian focus, at the upper end of one of the fork arms, where spectrographs and other accessories can be used.

The third is a coude arrangement. Here again a convex secondary mirror is used, but with a shallower curve giving a longer equivalent focal length. Four plane mirrors direct the light down the hollow polar axle and into either of two air-conditioned spectrograph rooms. One of these spectrographs, which uses a 47-inch mirror, gives grating spectra with a scale of two angstroms per millimeter in the third order. This very high dispersion will permit a wide variety of detailed studies of stellar spectra.



ASTRONOMICAL SCRAPBOOK

The Trapezium in Orion

SITUATED in the brightest part of the great Orion nebula is the 4th-magnitude star Theta Orionis. The earliest definite record that it is a multiple object is in Christiaan Huygens' book on Saturn (1659). There he describes an observation he made in 1656 with a refractor 23 feet long, fitted with a single-lens objective. Turning by chance this primitive telescope on the sword of Orion, he was struck with wonder at the nebulosity wreathed about Theta, which he noted as "three stars, nearly touching one another."

Later, on January 8, 1684, he found with a 34-foot telescope that this group consisted of not three but four stars, a fact independently established by G. D. Cassini at Paris. The last observation Huygens made before his death in 1695 was a sketch map of these four stars and their surroundings.

"Perhaps no object in the sidereal heavens has received more attention from astronomers than the multiple star θ *Orionis,*" wrote the American double star specialist S. W. Burnham late in the 19th century. This attention had led to the prompt discovery of other, fainter members of the group, as soon as telescopes of adequate power became available. A fifth star, labeled **E** on the chart, was added by Wilhelm Struve with the 9½-inch Dorpat refractor in 1826. The sixth, **F**, was found by Sir John Herschel on Christmas Day, 1832, with his 18-inch reflector.

These discoveries attracted the widest attention among Struve's and Herschel's contemporaries, for this was a time when double star astronomy was rapidly growing in popularity. In addition to professional astronomers at many observatories, well-equipped amateurs such as Admiral Smyth and W. R. Dawes were enthusiastically beginning to measure double stars. There were many others less qualified who scanned the Trapezium in hope of new discovery.

Burnham tells the result: "Certainly no equal area in any other part of the sky has furnished room for the location of so many purely imaginary stars. At intervals during the last fifty years [this was written in 1889] various observers have recorded a number of stars in the space enclosed by the four bright stars of the trapezium. As a rule these alleged discoveries have been made with small telescopes, even down to four inches' aperture, and by observers with little or no experience in double-star work. As would be expected, perhaps, in an object as carefully studied as this has been for the last twenty or thirty years, all the large and most perfect modern refractors, directed by the most experienced double-star observers, have utterly failed to show, under the best atmospheric conditions, the least trace of a single one of the dozen or more supposed new stars. The great 26-inch at Washington, until recently the most powerful telescope in the world, revealed nothing to Hall in the course of a long series of measures of the known stars of this group. The other large telescopes in this country – the McCormick 26-inch, the Princeton 23-inch, the Chicago 18½-inch, the Madison 16-inch, and the Harvard 15½-inch – were equally unsuccessful."

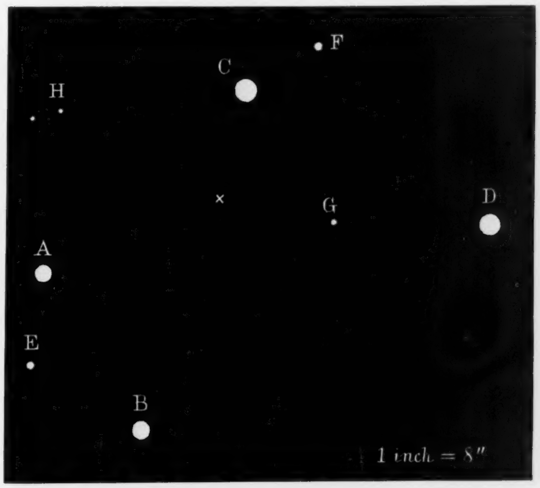
So strongly worded is this verdict that it seems an act of kindness not to name the hapless would-be discoverers! It is, however, a fact that the detection of a genuine seventh star in the Trapezium had to await the availability of a far more powerful instrument than any Burnham mentions.

In 1888, just after the 36-inch Lick refractor had been mounted, Alvan G. Clark, who had made its objective, visited Mount Hamilton to test his work. One of the first objects examined was the Trapezium, and he noticed at once a very faint speck of light, marked **G** in the accompanying chart. Subsequently Burnham repeatedly saw and measured it. Close to the threshold of visibility of the 36-inch, it was visible only on nights when the seeing was first class.

That October with the same telescope, E. E. Barnard added the 16th-magnitude member **H** to the group, and found that this exceedingly faint object was itself double. His fellow observer, Burnham, describes it: "On a remarkably perfect night, I saw the minute pair well, though with great difficulty, and obtained a fairly good measure. As a double star it is quite unlike anything known in the heavens, and the severest possible test for the defining and illuminating power of the large telescope. I have only been able to see it once."

No one else has done so since, apparently, for Aitken's double star catalogue lists no later data for Barnard's pair. But the ultima Thule in the Trapezium group is an unnamed star whose place in the map is indicated by a cross. Barnard's exceptionally keen eye glimpsed this even fainter star on two nights in 1888-89 with the 36-inch refractor, an object so excessively difficult that even Burnham could never see it definitely. There appears to be no later record of any search for it.

What about photographic confirmation of these faint specks of light? Unfortunately, on ordinary plates taken with fast modern instruments they are drowned out by their vastly brighter neighbors, and by the nebula. However, K. A. Strand in 1957 prepared a chart showing Theta Orionis, from infrared photographs made at Yerkes Observatory and at the Flagstaff station of the U. S. Naval Observatory. His map does show Clark's **G** and the pair **H**, but not Barnard's unnamed star. In infrared light the nebulosity is suppressed, and no longer masks the stars involved in it.

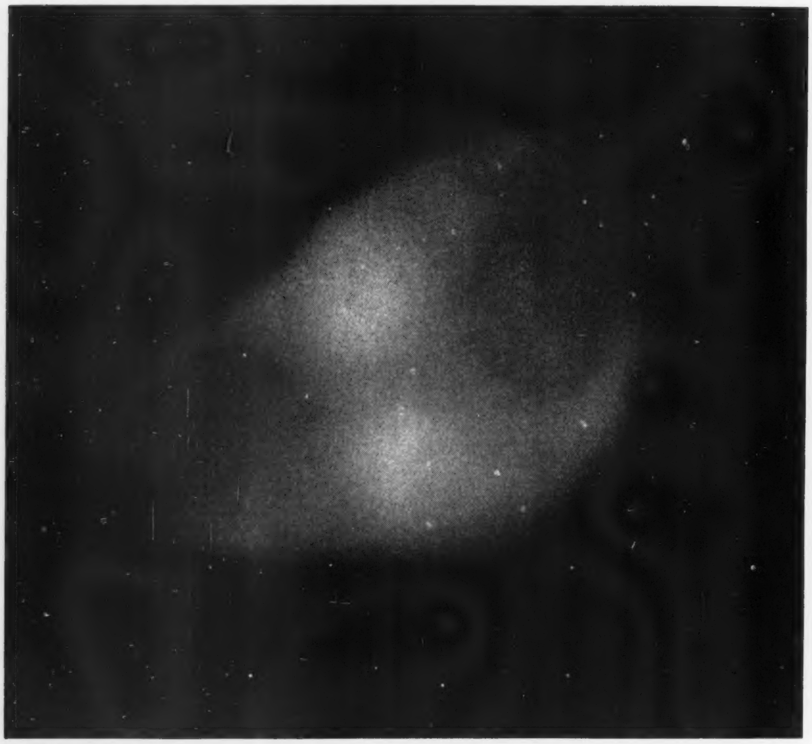


This map of the multiple star Theta Orionis was drawn by S. W. Burnham to indicate the locations of the faint members discovered at Lick Observatory. Stars A, B, C, and D form the Trapezium itself. The star designations are those in current use. The scale is the same as in the original diagram that appeared in Vol. 49 of the "Monthly Notices," Royal Astronomical Society (1889).

In recent years, the Trapezium has not been neglected by astronomers working with more rewarding, newer techniques in double star observing. The **B** component has been found to be an eclipsing binary, for example, and extremely precise photographic measurements have been made of the relative locations of the brighter members. Nevertheless, the visual last word on Barnard's discoveries seems to be over 70 years old!

JOSEPH ASHBROOK

Shown here as photographed at Mount Wilson Observatory, the Owl nebula has two "eyes" that are difficult features to detect visually.



The visual appearance of the Dumbbell nebula in Vulpecula is displayed in this drawing, made by Leopold Trouvelot about 1874 with the 15-inch refractor of Harvard Observatory. The faint extensions or lobes are perhaps too bright, at least in comparison with the photograph opposite.

An Amateur's Tour of Planetary Nebulae

LELAND S. COPELAND

AMONG the strangest objects in our galaxy are the infrequent planetary nebulae. These glowing gas clouds are of tremendous size, yet so rarefied as to be practically nonexistent when compared with objects of ordinary human experience. Though many of them occupy space more than a hundred times greater than our solar system, each is the quintessence of emptiness.

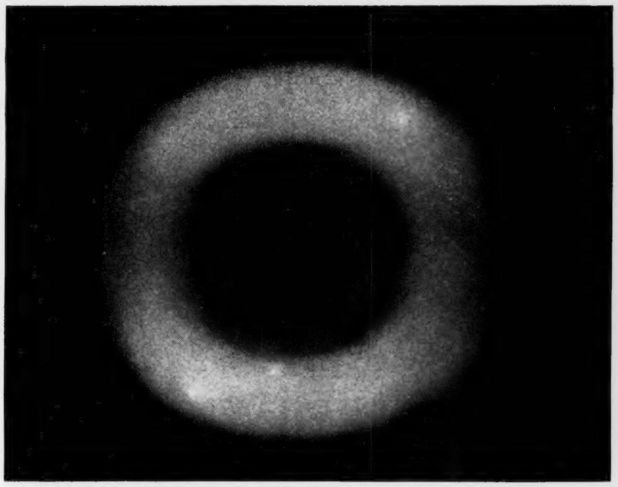
With few exceptions, planetaries are isolated from their fellows and lost amidst the lesser stars. Though still called by the name Sir William Herschel used — because to him they looked like planets' disks — they differ considerably in appearance among themselves. In fact, planetaries come in almost as many curious shapes as did Proteus, the tricky old man of the sea in Homer's *Odyssey*.

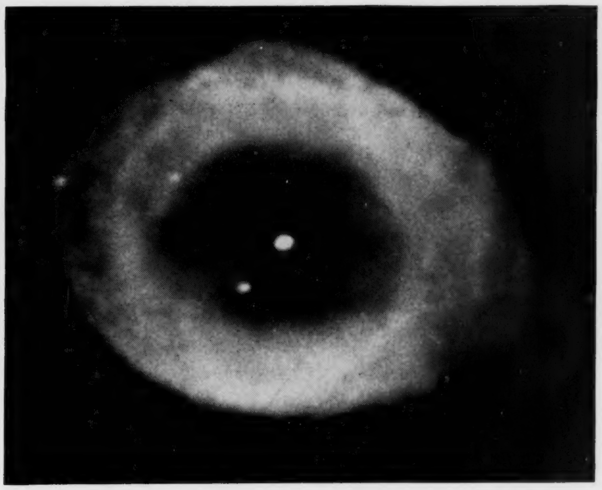
The Owl nebula (Messier 97, in Ursa Major) appears in photographs as a disk with dark markings; the Ring (M57, in Lyra) resembles a doughnut, even in small telescopes; and the Crab (M1, Taurus) suggests, in a Mount Wilson picture, a holiday turkey ready for the table. Handsomest of all its kind, the Dumbbell (M27, Vulpecula), which was named with the Owl and Crab by Lord Rosse, looks like a comfortable pillow.

Less well-known planetaries resemble a snowball, a cork, a blue egg, a gray spot, a snail or corkscrew, and even a flower. But as the amateur peers more deeply into interstellar space, the specimens shrink till they appear as soft, fuzzy stars. Except for some two dozen among the nearest and largest of the 500 planetaries that have been discovered, in amateur telescopes they are scarcely distinguishable from stars.

Yet they can be identified by the users of spectroscopes, for planetaries are among the original fluorescent lamps, shining by stimulation. Their gases — mainly hydrogen, nitrogen, oxygen, and neon — are excited by invisible ultraviolet light from the star at the center of each planetary. This excitation causes the soft radiance we see across distances of thousands of light-years.

These marvelous objects seem to have resulted from tragedies that occurred, in many cases, thousands of years ago. Most





At the left is a Trouvelot drawing of the Ring nebula in Lyra, as seen in Harvard's 15-inch telescope. Compare it with the one-hour photograph at the right, taken with the 100-inch Mount Wilson Observatory reflector in August, 1921. The 15th-magnitude central star is so blue that it is much more conspicuous photographically than it is to the eye. The interior haze and the diffuseness of the ends of the oval can be recognized in an 8-inch telescope without much difficulty. In a 3-inch glass this nebula resembles an out-of-focus 8th-magnitude star.

The Crab nebula in Taurus is the expanding debris of a star that blew up about 900 years ago. This Mount Wilson and Palomar Observatories photograph was taken by W. Baade with the 100-inch telescope. Other pictures by him, in red light, show a remarkable network of bright filaments, unrecognizable visually.

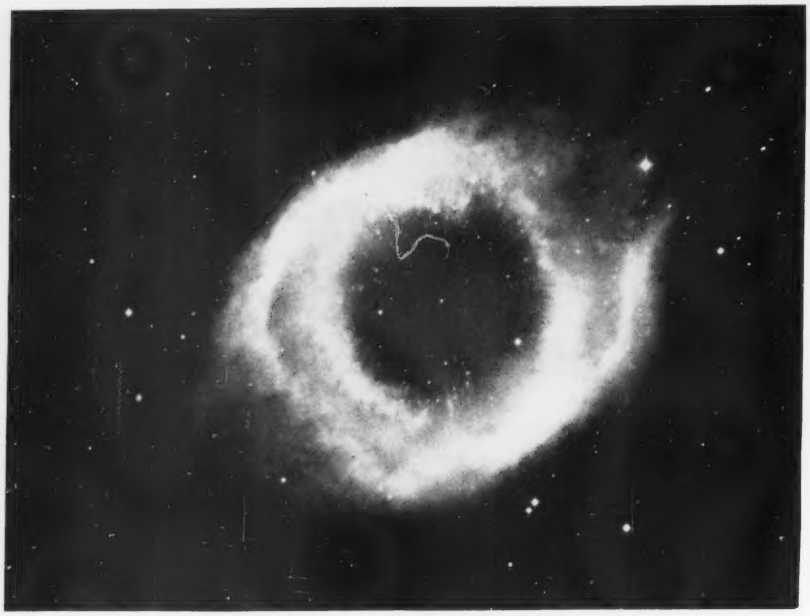
astronomers feel that a planetary nebula is formed when the intensely hot central star either explodes or ejects in some slower way a considerable part of its substance. The expelled material continues to move ever outward. The Crab nebula, for instance, is believed to have originated in the outburst of a supernova in A.D. 1054, then looking like a star brighter than Jupiter to astonished observers in the Far East.

As planetaries expand, they become more and more tenuous until they gradually disappear in the vastness of interstellar space. The Veil or Network nebula in Cygnus, so well shown in the center spread of the January, 1957, SKY AND TELESCOPE, is disintegrating and approaching oblivion, though the original shape is still detectable. This filamentary object probably resulted from an explosion taking place over 100,000 years ago.

An amateur observing planetaries cannot expect to spy the details visible in photographs. After seeing the dark center of the Ring and, under very exceptional conditions, suggestions of eyes in the Owl, he must be satisfied with mere outlines. Moreover, the hunt for these nebulae often is exasperating, because the specimens seem to tantalize observers, so that a half hour's search may be needed to find a particular planetary. Even if the telescope has setting circles, patience and perseverance may be required. Like Wordsworth's Lucy, planetaries dwell "among the untrodden ways" and are marvels for "very few to love." Because of this elusiveness, when a particular planetary has once been found the amateur should plot a path among the stars to help him find it more quickly the next time.

Except for the "Major Four" — the Dumbbell, Ring, Crab, and Owl — plane-

Compare this photograph of the Dumbbell in Vulpecula with Trouvelot's drawing on page 214. This is a 30-minute exposure with the Naval Observatory's 40-inch reflector at Flagstaff, Arizona, in September, 1956. U. S. Navy photo.



Intricate internal structure in the giant planetary NGC 7293 is shown by this photograph Baade took in red light with the 200-inch telescope. Note the very faint central star. Mount Wilson and Palomar Observatories photograph.

taries test not only the skill of the observer but the reach of his instrument. The "Minor Five" are the next least difficult and consist of objects in Aquarius, Perseus, Puppis, and Hydra.

The Helical nebula in Aquarius (NGC 7293) can be seen with a 4½-inch reflector if it is viewed in a clear, dark, country sky. Though this is the largest planetary, with a diameter half that of the full moon, its faintness may hide it from sight, even in a 12-inch, if the air is misty or if city lights interfere.

Another member of this group is the "Little Dumbbell," M76 in Perseus, somewhat resembling a cork. It can best be found by starting from Phi Persei. This star and a dimmer one close by form a pointer, with ϕ at the head, that directs the observer to a diamond of faint stars, within which M76 is dimly perceptible.

The minor group includes NGC 2438, easy to find near the edge of the rich galactic cluster M46, in northern Puppis. South of this rather indistinct planetary is another, NGC 2440 (labeled 64' in Norton's *Star Atlas*), hard to find even in an 8-inch telescope, as there are no distinctive configurations of bright stars nearby.

The Minor Five list is completed by NGC 3242 or 27' in Hydra, looking like a bluish egg. Start from the orange star Mu Hydrae, and move south along a winding starry trail until you arrive at a small triangle formed by two dim stars and the planetary itself.

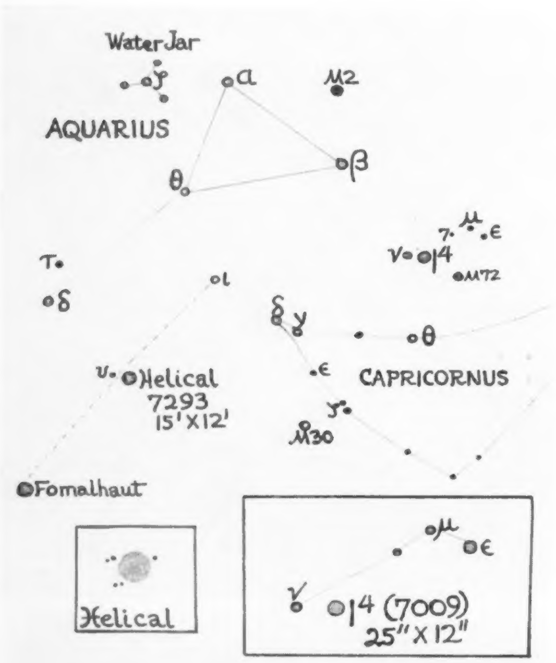
Owners of 6-inch telescopes or smaller probably will not be able to go much farther in the pursuit of planetaries. The "Four Midgets" — in Cygnus, Draco, Andromeda, and Aquarius — require an 8-inch or larger, though with a very clear sky a 6-inch will show the last two: NGC 7662 and 7009.

Beyond the end of the western arm of the Northern Cross, near Theta Cygni, is the small gray spot NGC 6826. On a chart this nebula is just east of θ, but seems far from it when finally spied among the many faint stars in this region.

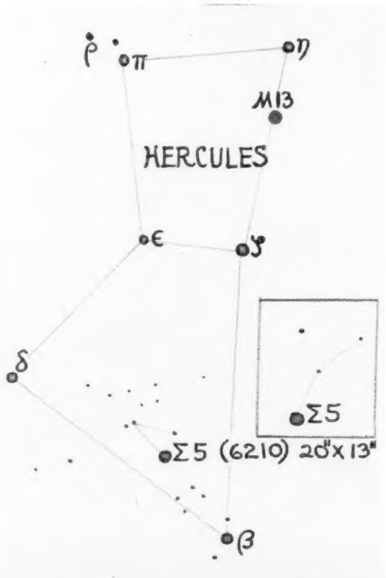
Another midget, NGC 6543, is between Zeta and Delta Draconis, just south of Draco's coil formed by Psi, Phi, and Chi. This blue spheroid, like a snail in photographs, won fame in 1864, when William Huggins' spectroscope proved it was a luminous body of rarefied gas.

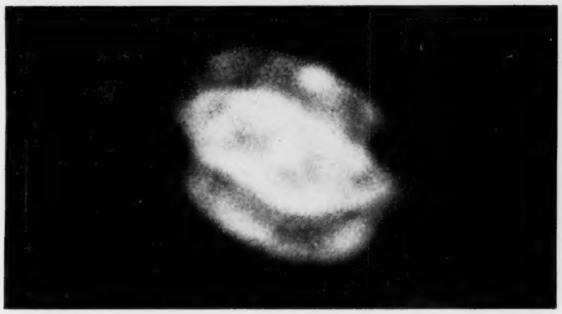
Looking like a light blue snowball, NGC 7662 lies west of Andromeda's hand, outlined by Psi, Kappa, Lambda, and Iota. The planetary is between the hand and Omicron Andromedae. On photographs, this nebula bears a fanciful resemblance to a lily.

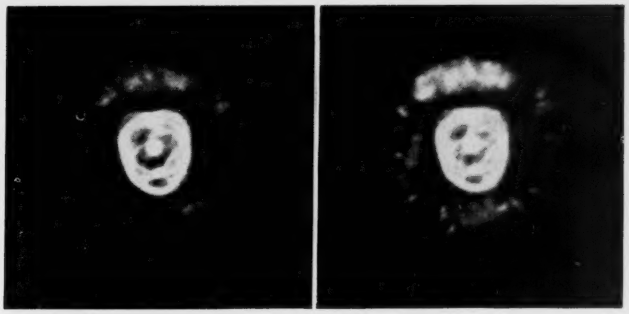
The Saturn nebula, NGC 7009 (1'), is above the back of Capricornus. A key to its position is the curved line of the stars Epsilon, Mu, 7, and Nu in Aquarius. This object, slightly resembling the planet Saturn, but not in amateur telescopes, lies 1½ degrees west of Nu. A successful search for it gives what a famous New York



The author has prepared these charts to aid in finding some of the planetaries he describes. There are two scales in each case: the broad configurations of the constellations and the smaller fields of binoculars or telescopes. At the left, in the Aquarius-Capricornus region, NGC 7009 and 7293 are marked, together with the places of three globular clusters, M2, M30, and M72. The right-hand map, of a portion of Hercules, shows the planetary NGC 6210 and the famous bright globular cluster M13.







Left: A picture of NGC 7009, in Aquarius, taken with the 60-inch Mount Wilson telescope, suggests why this object is popularly called the Saturn nebula. Right: Two views of NGC 2392 in Gemini, photographed in green and red light, respectively, with the 200-inch telescope. Mount Wilson and Palomar Observatories photographs.

cartoonist used to call "that grand and glorious feeling."

After the Midgets come the following 11 "Minikins":

NGC 1501 (53^4), Camelopardalis. A faint gray spot in amateur telescopes, but on photographs somewhat like a flower. Also look $1\frac{1}{2}$ degrees south for the delicate "Golden Harp" cluster, NGC 1502.

NGC 1535 (26^4), Eridanus. Four degrees east of the orange star Gamma Eridani, which makes a useful point of departure.

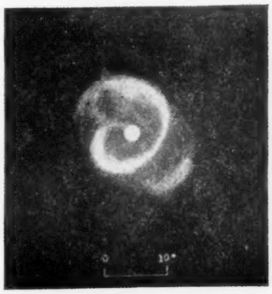
NGC 2022 (34^4), Orion. Near the head of the Giant, west of Betelgeuse.

NGC 2371-72, Gemini. A very faint double planetary, making a triangle with Castor and Pollux, and west of them.

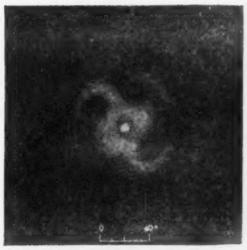
NGC 2392 (45^4), Gemini. Close to Delta Geminorum; relatively bright, with a disk about as large as Jupiter's.

NGC 4361 (65^1), Corvus. Inside the quadrilateral of the Crow, and forming an isosceles triangle with Gamma and Delta Corvi.

NGC 6210 ($\Sigma 5$), Hercules. A small bright disk, between Delta and Beta Herculis, but nearer the latter.



These two drawings of planetaries were made by Heber D. Curtis from photographs taken at Lick Observatory early in this century. On the left is NGC 6543, with coils like a snail's, and on the right NGC 4361, one of the author's Minikins, of very low surface brightness.



NGC 6369 (11^4), Ophiuchus. Near Theta and the center of our galaxy. Described by R. C. Richard, Santa Barbara, California, as faint, grayish, and roundish.

NGC 6572 ($\Sigma 6$), Ophiuchus. Fairly bright but very small; located south and east of the stars 71 and 72 Ophiuchi.

NGC 6781, Aquila. Forms a right triangle with Mu and Delta Aquilae, in the heart of the Eagle. Very hard to find, because it is faint and isolated.

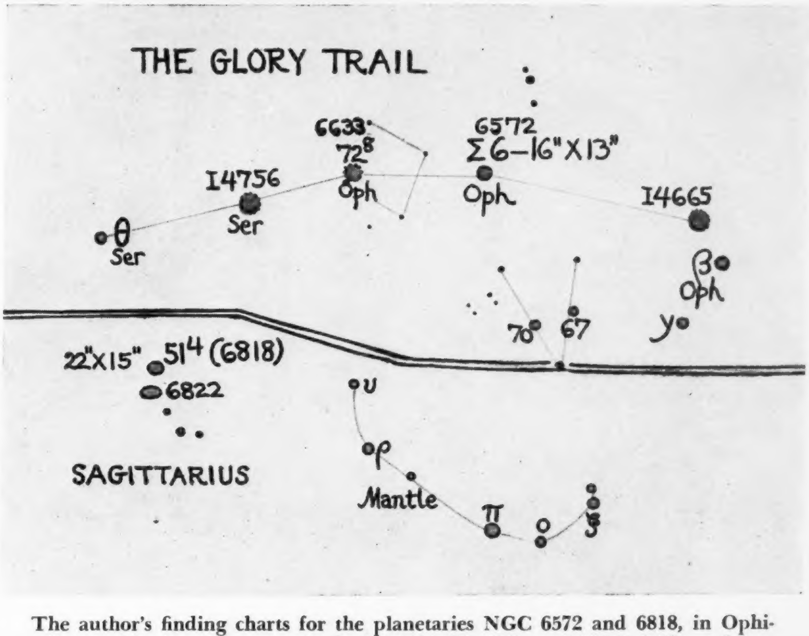
NGC 6818 (51^4), Sagittarius. East of the "Mantle," the curving line of stars made by Xi, Omicron, Pi, Rho, and Upsilon Sagittarii. (It is also situated near the faint dwarf system NGC 6822, a member of the local group of galaxies.) Beyond the reach of a 6-inch even in clear mountain air, but easy with a 12-inch.

If you will look doggedly until you have been able to bring in most of the planetaries listed here, you will have new reason for counting yourself among those whom the French astronomer Camille Flammarion called "citizens of heaven."

FINDING LIST OF PLANETARIES

NGC	*R.A. (1950)*		*Dec.*		*Size*		
	h	m	°	′	″		″
650-51	01	38.8	+51	19	157	×	87
1501	04	02.6	+60	47	56	×	48
1535	04	12.1	−12	52	20	×	17
1952	05	31.5	+21	59	360	×	240
2022	05	39.3	+09	03	28	×	27
2371-72	07	22.4	+29	35	54	×	35
2392	07	26.2	+21	01	47	×	43
2438	07	39.6	−14	36		68	
2440	07	39.9	−18	05	54	×	20
3242	10	22.4	−18	23	40	×	35
3587	11	12.0	+55	18	203	×	199
4361	12	21.9	−18	29		81	
6210	16	42.5	+23	53	20	×	13
6369	17	26.3	−23	44		28	
6543	17	58.8	+66	38		22	
6572	18	09.7	+06	50	16	×	13
6720	18	51.7	+32	58	83	×	59
6781	19	16.0	+06	26		106	
6818	19	41.1	−14	17	22	×	15
6826	19	43.4	+50	24	27	×	24
6853	19	57.4	+22	35	480	×	240
7009	21	01.4	−11	34	44	×	26
7293	22	27.0	−21	06	900	×	720
7662	23	23.5	+42	14	32	×	28

M76 is NGC 650-51; the Crab, 1952; Owl, 3587; Ring, 6572; and Dumbbell, 6853.



The author's finding charts for the planetaries NGC 6572 and 6818, in Ophiuchus and Sagittarius, respectively. IC 4665, IC 4756, and NGC 6633 are large, bright star clusters; NGC 6822 is a dim galaxy.

NEWS NOTES

JOHN A. ANDERSON DIES

The man who supervised the grinding and polishing of the 200-inch mirror for the Hale telescope at Palomar Observatory passed away last December 3rd at Altadena, California. John A. Anderson was 83 years of age.

His first astronomical work was as a member of the U. S. Naval Observatory's eclipse expedition to Spain in 1905. Dr. Anderson joined the Mount Wilson Observatory staff in 1916, and for 15 years was chief optical worker for that institution. From 1928 to 1948 he was executive officer of the California Institute of Technology's observatory council.

Dr. Anderson organized the optical work on the 200-inch in the Caltech shops, and he supervised five years of seeing tests on Palomar Mountain before final selection of that site. In January, 1948, when the initial visual and photographic tests of the huge reflector were made, Dr. Anderson was the first person to observe the image formed by the primary mirror.

He was famed as a successful maker of precision diffraction gratings for spectroscopes. He was also interested in earthquakes and the construction of seismometers.

POLARIS AND THE POLE

As the north celestial pole describes its giant circle of precession in the sky, requiring 25,800 years for one revolution, when will it pass nearest to the North Star, Polaris, and how close? The method for computing this and the best obtainable current prediction are given by Brown University astronomers Charles H. Smiley and Abdul Majid Khan in the December, 1959, issue of the *Journal* of the Royal Astronomical Society of Canada.

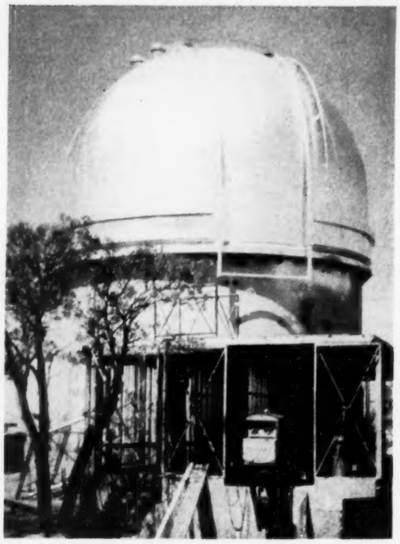
They find the mean polar distance of Polaris will be least in the year 2102, but its value then of 0° 27′ 31″.50 differs from those for the preceding and following years by only a few hundredths of a second of arc. Well before that time, improved values of the precessional constants should permit a more precise determination of the date and distance of the closest approach.

The article also contains charts of the paths of both the north and south celestial poles, from which it may be seen that our next north pole star will be Gamma Cephei, about A.D. 4145, then Alpha Cephei, about 7530. The south pole, which has no bright pole star now, will have Omega, Upsilon, and Iota Carinae, and Delta Velorum, in the years 5770, 6850, 8075, and 9240, respectively. The last is a 2nd-magnitude star.

84-INCH MIRROR BLANK BEING GROUND IN TUCSON

Optical processing is now under way on the Kitt Peak 84-inch mirror blank at the National Observatory's shop in Tucson, Arizona, where grinding and polishing will take about two years.

Final precision figuring, involving removal of a few millionths of an inch of glass, will be undertaken after the mirror has been temporarily installed in the telescope atop Kitt Peak and tested on a star. The figuring is expected to take another year, according to A. B. Meinel, the observatory director.



Shortly prior to its completion, the building for the 36-inch Kitt Peak reflector was photographed by Donald J. Strittmatter, of Tucson, Arizona.

Pouring of the 4,000-pound honeycombed pyrex glass disk was described on page 318 of the April, 1959, SKY AND TELESCOPE. Seven months were required in the annealing oven, where its temperature was gradually reduced, and last fall Corning Glass Works shipped the blank from New York to Arizona by railroad in a special felt-lined crate.

Meanwhile, work is essentially complete on the 36-inch reflector of the National Observatory. Installation of the telescope in its building was scheduled for January, and the auxiliary buildings were to be finished at about the same time.

Dr. Aden B. Meinel, director of the National Observatory at Kitt Peak, Arizona, inspects the glass blank for the mirror of the 84-inch reflector. Note the weight-saving honeycombing of the under part of the pyrex disk.

A RAPIDLY VARYING STAR

A 9th-magnitude star in Canis Minor is the latest addition to the brief but important list of intrinsic variable stars with very short periods. They undergo rhythmic changes in brightness like those of RR Lyrae, but with periods as short as 1½ to four hours.

Hitherto this object, AD Canis Minoris, had been supposed to be an eclipsing variable of the Algol type, with a period of 1.276 days. Therefore, at Leuschner Observatory in Berkeley, California, K. D. Abhyankar had included the star in a list of eclipsing systems to be observed photoelectrically with the 20-inch reflector. His purpose was to obtain a complete light curve from which the elements of the binary system could be computed.

To his surprise, AD Canis Minoris showed a continuous light variation in a period of only two hours, 57.1 minutes, with the rise from least to greatest bright-

IN THE CURRENT JOURNALS

THE PROBLEM OF LIFE IN THE UNIVERSE AND THE MODE OF STAR FORMATION, by Su-Shu Huang, *Publications*, Astronomical Society of the Pacific, October, 1959. "Therefore it is reasonable to believe that from the masses of the fainter components of binary stars to those of planets there exists a continuous range without any sharp demarcation. Since binaries are so numerous in the Galaxy, comprising more than half of the stellar population, we would naturally expect that planetary systems are not rare."

THE ARMS OF THE GALAXY, by Bart J. Bok, *Scientific American*, December, 1959. "The final solution to the problem of spiral structure will probably come from coordinated optical and radio studies of our galaxy, where detailed features obscure the over-all pattern, and of nearby spiral galaxies, where the pattern is clearly visible in all its majesty."

ness taking about half this long. In addition, G. Wallerstein made spectrographic observations with the 60-inch Mount Wilson reflector, showing that the spectrum of the variable changed from type *F0* at maximum light to *F3* at minimum – a behavior typical of pulsating stars with very short periods.

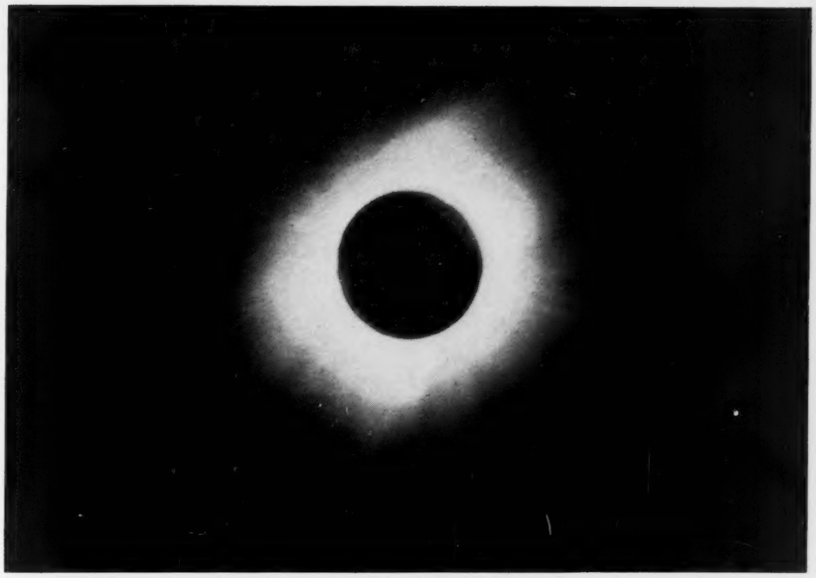
The visual magnitude range is relatively small, from 9.08 to 9.38. This variable's 1950 position is $7^h\ 50^m.2$, $+1°\ 44'$; it is only $1^m.1$ east and 10′ south of the 5th-magnitude star Zeta Canis Minoris. Dr. Abhyankar has reported his observations in detail in the November, 1959, issue of the *Astrophysical Journal*.

DEATH OF P. P. PARENAGO

A world-famous authority on variable stars and galactic structure, Pavel P. Parenago, died on January 6th at the age of 53. He had been professor of stellar astronomy at Moscow University for 26 years, and was a member of the Academy of Sciences of the U. S. S. R.

About the year 1930, Parenago became one of the leaders in the group of younger Soviet astronomers who began such intensive observations of variable stars that the world center of research in that subject eventually shifted from Germany and the United States to Russia. He was a co-editor of the journal *Variable Stars*, and of the monumental *General Catalogue of Variable Stars*, whose 1958 edition contained 14,708 entries.

Among the most important of Parenago's publications was his 1954 monograph on the Orion nebula and the stars within it. This was a 547-page work that formed Vol. 25 of the *Publications* of the Sternberg State Astronomical Institute.



The beautiful corona surrounding the totally eclipsed sun last October 2nd, photographed by Fritz Laudenklos, of Cologne, West Germany, who observed in the Canary Islands. He used a 21-cm. f/4.5 Tessar lens, one-second exposure.

German Amateurs View Eclipse

EDGAR MÄDLOW, *German Amateur Astronomers Association*

UNDER the name Operation Canaria, the German Amateur Astronomers Association sent an expedition to the Canary Islands to observe the total solar eclipse of October 2, 1959. It was our second undertaking of this sort, the first being a successful journey to Sweden for the June 30, 1954, eclipse. There were 32 participants, from both West and East Germany, all being amateurs with the exception of Mrs. M. Mädlow of the Potsdam Astrophysical Observatory.

To improve the chances of success, the expedition occupied two separate stations in the Canaries. Twenty-three of us set up our instruments on a former fortification 50 meters above the city of Las Palmas on Gran Canaria. The other nine chose the fishing village of Morro de Jable in southwestern Fuerteventura, about two kilometers east of the American expedition's observing site. The duration of totality was 123 seconds at Las Palmas, and 154 at Morro de Jable.

Each group had for its main instrument a Zeiss quadruple camera of 63-mm. aperture and 500-mm. focal length. We planned to take photometrically calibrated photographs of the corona in three planes of polarization and in two spectral re-

Nine members of the expedition set up their quadruple camera at Morro de Jable, but weather conditions prevented viewing the corona from this location. The canopy in this photograph by the author also serves as a windscreen for the observing instruments.

The observing place of one of the German groups, on Guanarteme Battery at Las Palmas. Packing cases protect the larger instruments from the incessant trade winds. Photograph by A. Matuschek, St. Wendel, Saar.

gions. The other instruments, with focal lengths of 50 to 1,200 millimeters, served for direct photography, partly in color, and for motion pictures. There were also wide-angle cameras with fields of 110 and 180 degrees, for recording the appearance of the earth and sky during the course of the eclipse.

On eclipse day, weather conditions were dominated by a cold front that was to cross the islands on the night of October 2-3, accompanied by severe storms. Already on the 1st high clouds had gathered, giving rise to a solar halo; on the 2nd we had an almost unbroken deck of low clouds, with occasional rain showers. At this time the chances of observing the eclipse at the two stations had sunk from 80 to five per cent.

During the eclipse the corona could not be seen at Morro de Jable; only the intense red of the chromosphere could penetrate the thinner spots in the clouds for a few moments. But the Las Palmas observers had almost incredible luck, for during precisely the interval of totality a break appeared in the clouds, and through it the eclipsed sun could be seen practically unhindered. For 110 of the 123 seconds the view was entirely clear.

This time was well used. Altogether 46 photographs of the corona and prominences were obtained, 18 of them in color. The motion pictures were unfortunately spoiled; we had only one movie camera at Las Palmas, and by mischance the same film was exposed twice. Nevertheless, six different color sequences of the landscape were secured, out of 19 exposures during totality.

Our expedition was accompanied by a German television camera group which set up at Cruz de Tejeda, at an elevation of 1,200 meters in the interior of Gran Canaria. Although there the clouds were more troublesome than at Las Palmas, they took successful movies of the corona, with focal lengths of 150 and 300 millimeters. The film was flown to Hamburg and telecast from there to the German public, on whom the beautiful corona made a great impression.

EDITOR'S NOTE: Three Americans from Nashville, Tennessee, also saw the eclipse at Las Palmas. Carl K. Seyfert, director of Dyer Observatory, with Mr. and Mrs. Dan May, was at the Jesuit college, taking successful 16-mm. color motion pictures of the total phase, using a 6-inch telephoto lens. The film was shown by Dr. Seyfert at the Cleveland meeting of the American Astronomical Society last December 29th.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is a PZT?

A. The initials stand for "photographic zenith tube," a stationary telescope that always points directly overhead, and records photographically the passage of faint stars across the meridian for accurate determinations of time and latitude.

Q. What is Stéphan's quintet?

A. It is a compact group of five faint galaxies in northern Pegasus, which has attracted much attention by astronomers. The group was discovered by H. Stéphan, who late in the 19th century searched visually for new nebulae with the $31\frac{1}{2}$-inch reflector of Marseilles Observatory, in France.

Q. What is meant by the star designations 80 B Psc and 136 G Psc, as in the December issue's Occultation Supplement?

A. These are stars in Pisces, bearing numbers assigned to them in the atlases of J. E. Bode (1801) and B. A. Gould (1879), respectively. Bode or Gould numbers are sometimes used for naked-eye stars lacking the more familiar Flamsteed numbers. 61 Cygni is an example of a Flamsteed number.

Q. Why are comets sometimes named by letters and sometimes by Roman numerals?

A. Newly found comets are assigned letters in the order of their discovery during a year; later, permanent number designations are given them to indicate the order in which the comets passed through perihelion. Thus the comet provisionally called 1955e is now listed as 1955 III.

W. E. S.

AN AMATEUR'S NIGHT OUT

(Continued from page 199)

of an exploding star, and that here, just where he has it pinned down, the Chinese in A.D. 1054 saw a "guest" star, a supernova whose wreckage has been spreading ever since.

Without watch or calendar the amateur can tell the time of night and the season of the year, by the steady-moving starry sphere above him. The sameness is never wearisome; there are timeless grandeur and eternal security in that wheeling procession. The Whirlpool galaxy he picks up in his 6-inch scope is perhaps four million light-years away. So, what time is it, anyway? Now? Tonight? Or four million years ago?

Early one evening Mars may be near the meridian and Venus low in the southwest sunset. At another time it will be Jupiter with its four pinpoint moons. The steady sky is not still or stolid; it is alive and moving all around the observer.

Even though he may sometimes deliberately wait until the early morning hours for a predicted meteor shower, it will be a rare night when the amateur does not see at least one sporadic "shooting star" cross his field, even as he peers at something else. There can be occasionally the sweep of a comet, but most comets are well publicized and belong to anybody. Less newsworthy, but a prize for the observer, are the quick occultations when the moon blots out a star or planet. And there are always conjunctions of two or more planets, or of a planet and a 1st-magnitude star, or of the rising thin slip of a crescent moon and a planet.

There can be northern lights, and, if the watcher is not mindful, those other lights — the gray and lime and lemon of sunrise — warning the stargazer that at last his wonderful, shining night out is over.

MRS. JOSEPH E. STEVENS
254 Rogers Ave.
W. Springfield, Mass.

Getting Acquainted with Astronomy

The Planets — Mercury – I

SCARCELY a third as large as the earth in diameter, Mercury moves around the sun at an average distance of only 36 million miles. Seen from the earth, it is always near the sun in the sky, the angular separation amounting to 28 degrees at the most. As a result, the casual sky viewer will seldom chance upon Mercury. Nevertheless, its reputation among amateur astronomers as an elusive object is undeserved.

Actually, the planet is readily seen with the naked eye at or near the times of greatest elongation (maximum angular distance from the sun). Ordinarily, for a week or two Mercury can be viewed in the twilight, glittering like a star of the 1st magnitude.

Almanacs and the Celestial Calendar of this magazine give the elongation dates, but such occasions are by no means equally favorable. The Graphic Time Table of the Heavens, printed in Sky and Telescope each January, shows the rising and setting of Mercury in relation to sunrise and sunset, indicating which elongations provide the most advantageous periods for seeing the planet in a fairly dark sky.

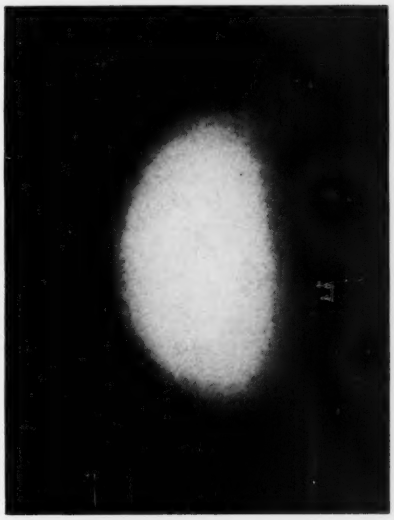
As an inferior planet — moving around the sun in an orbit inside the earth's — Mercury presents a cycle of phases similar to the moon's, from full to new to full again. Its synodic period is the interval required for one complete phase cycle and averages 116 days, nearly a month longer than the planet takes to revolve around the sun.

Let us trace the behavior of Mercury over a synodic period, taking for example the one beginning with the superior conjunction of the planet and the sun on January 26, 1960. At that time Mercury is on the other side of its orbit from us, beyond the sun, and so close to it in the sky that the planet cannot be seen, even though its phase is full.

Then, during the early days of February, the planet gradually moves ahead of the sun to the east, setting about an hour after it by the middle of the month. During this time, Mercury's phase is gibbous and it is very bright, of apparent magnitude −1.1. On February 24th, the planet attains greatest eastern elongation, 18 degrees east of the sun, and is visible in the evening sky until the end of twilight. It is a magnitude fainter, however, and fading rather rapidly. Telescopically, its disk is half illuminated, like a tiny first-quarter moon, and thereafter it is a waning crescent.

Mercury continues to move eastward among the stars until March 1st, when it is stationary before turning westward. As the sun itself is continuing its apparent eastward movement, the two objects approach each other very quickly, and by March 10th Mercury is at inferior conjunction. At that time it passes between the sun and the earth, appearing as a very slender crescent. For because of the tilt of its orbit to the earth's, Mercury does not cross the sun's disk, passing to the north of it instead.

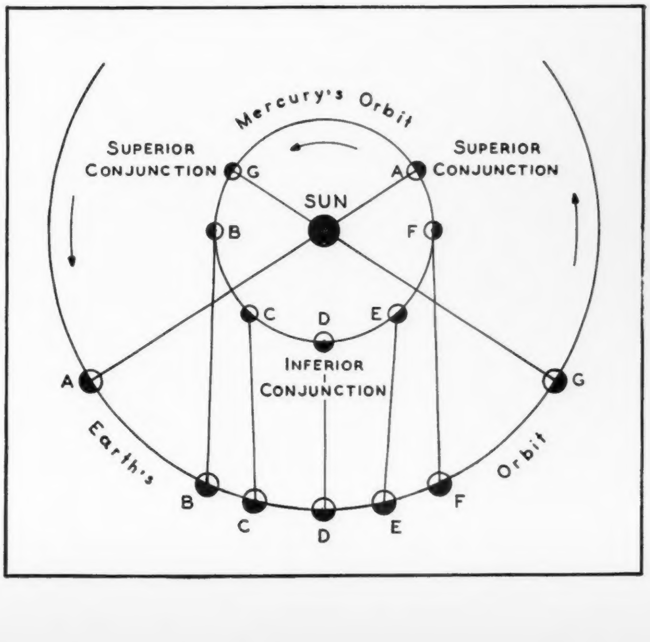
After inferior conjunction, the planet is west of the sun, a waxing crescent in the morning sky. It is again stationary on March 23rd, when its apparent motion changes from westward to eastward. Then, on April 7th, Mercury reaches greatest western elongation, 28 degrees from the sun in the dawn sky, and near last-quarter phase. Afterward, the planet's phase is gibbous, like the moon between last quarter and full, and by May 17th superior conjunction is again attained, on the far side of the sun, completing the synodic period that began on January 26th.

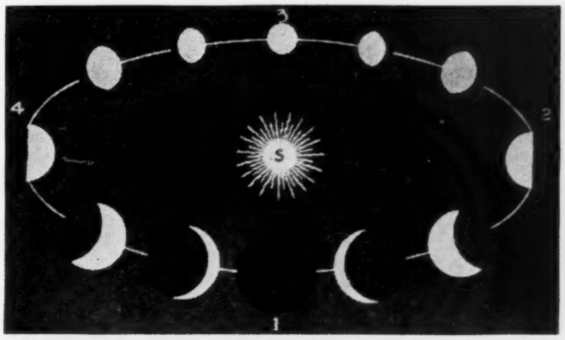


The planet Mercury, photographed with the 24-inch refractor of Lowell Observatory, Flagstaff, Arizona. The planet's phase here is gibbous: between half illuminated and full. The surface markings of Mercury are delicate dusky streaks that offer little contrast to the reddish disk. Lowell Observatory photograph.

It will be noted from this schedule that the greatest elongation distance varies considerably. The actual range, 18 to 28 degrees from the sun, is due primarily to the markedly elliptical shape of Mercury's orbit around the sun, the separation of the two bodies ranging from 29 to 43 million miles.

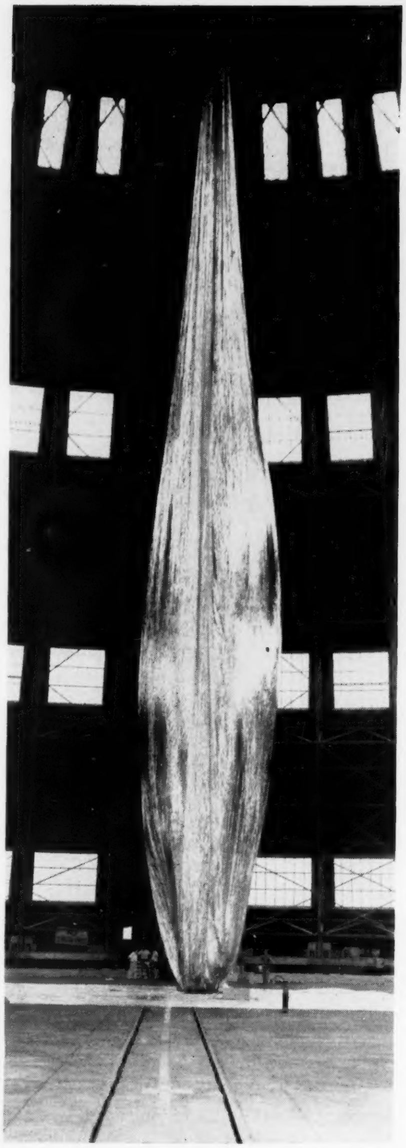
(To be continued)





Mercury's apparent size and phases as seen from the earth are shown above. Position 1 is inferior conjunction; 2 is western elongation (morning sky); 3 is superior conjunction; 4 is eastern elongation (evening sky). At the left are sketched the relative positions of Mercury and the earth in a synodic cycle, the two orbits being assumed circular. A and G correspond to 3 above, B to 4, D to 1, and F to 2. C and E are stationary points, at which Mercury changes its apparent direction of motion in the sky. The diagram at the left is adapted from Camille Flammarion's book, "Astronomie Populaire."

OBSERVING THE SATELLITES



The Project Echo balloon is made of a very thin plastic film. A make-up gas system will be retained inside the satellite to keep it inflated despite possible meteorite punctures or leakage through the skin. The fully inflated sphere is pictured opposite.

Project Echo

A NEW SERIES of bright artificial satellites, to be readily visible to the unaided eye from nearly every part of the world, has recently been announced by the National Aeronautics and Space Administration. In the first Project Echo launching, now planned for early spring from Cape Canaveral, a 100-foot inflatable balloon will be shot into a high-inclination, high-altitude orbit.

The primary purpose of the aluminized plastic sphere is to serve as a passive radio-communications link over ranges of thousands of miles; it may also yield information about rapid local variations in atmospheric density.

The spring Project Echo shot will be the first application of a new launching vehicle known as Delta, which has been under intensive development for many months. Two other inflatable spheres are planned for the Echo series, and many additional experiments are to be carried aloft by Delta vehicles.

The large spherical balloon is made of 0.0005-inch-thick Mylar plastic that has been aluminized in a vacuum to provide good reflectivity for radio waves – 98 per cent at frequencies up to 4,000 megacycles per second. Weighing about 150 pounds, it will be folded inside a container 28 inches in diameter. When orbital velocity is attained, this container is to be opened by explosive bolts, and the residual air inside the balloon will begin to inflate it. Evaporation of only about two quarts of water in a plastic bag within the sphere will complete the inflation, this amount sufficing because the satellite will be orbiting in a region where the atmospheric density is of the order of only 10^{-17} gram per cubic centimeter.

Successful tests of the inflation system were made on October 28, 1959, when a 100-foot sphere was shot aloft from Wallops Island, Virginia, but no attempt was made to place the sphere in orbit. Earlier efforts to send up 12-foot balloon satellites were failures.

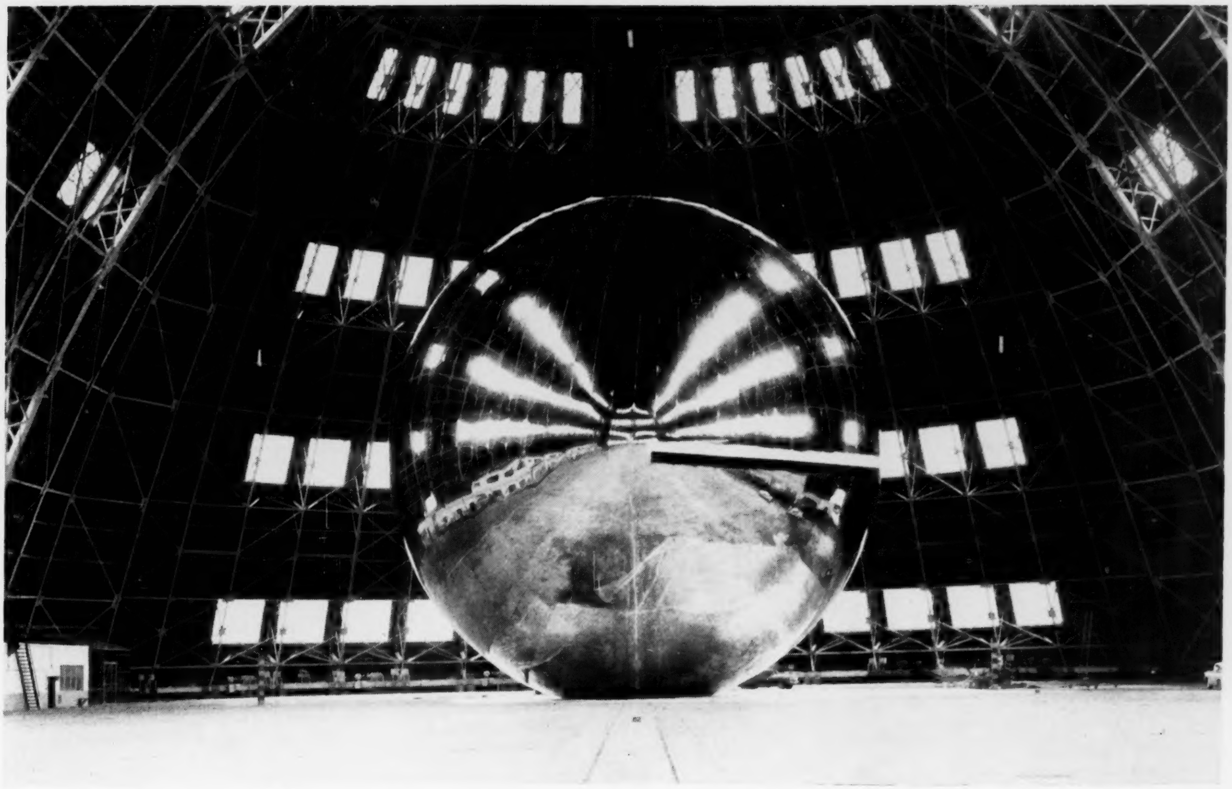
Because of the danger that a meteorite may puncture the 100-foot bag, it will probably carry a readily sublimed solid to provide make-up gas. In this way, the balloon would remain spherical for perhaps a week after such a puncture.

Present plans call for an orbit inclined about 50 degrees to the plane of the earth's equator, and with a period of two hours. At its height of over 1,000 miles, the satellite will be simultaneously within line-of-sight range of two experimental radio stations on the east and west coasts of the United States. In California the Goldstone tracking station is to transmit 2,390-megacycle signals, and in New Jersey a Bell Telephone Laboratory transmitter will be operating at 960 megacycles. The transmissions from each station will be reflected from the balloon and received by antennas at the other site.

This radio experiment is of great practical importance. The present frequencies suitable for global radio communications are almost saturated with traffic. Use of higher frequencies would give not only additional channels, but each of these could carry more information. The great difficulty has been that high frequencies are not reflected by the ionosphere and can be received only over straight-line paths, not around the curve of the earth. One proposal for a communications relay is a satellite 24,000 miles above the equator that would remain stationary relative to the earth's surface beneath it. The savings from its use would more than pay for the cost of putting it aloft. Several other plans are also being considered.

This 28-inch package contains the uninflated 100-foot sphere seen in the upper-right picture. After release in space, the balloon will be inflated with air and water vapor. National Aeronautics and Space Administration photos.

The great expected brightness of the aluminized balloon should make it a particularly interesting object for optical satellite trackers, and for others who enjoyed watching the bright satellites of a year and more ago. When fully inflated, it may slightly outshine Vega, our fifth brightest star, and whenever it is fully outside the earth's shadow, it will be at



For ground tests some 40,000 pounds of gas are required to inflate the plastic sphere, but in orbit only a few pounds will be needed. The exterior surface is coated with aluminum. NASA photograph.

least a match for stars of magnitude +3.3 in the same part of the sky.

For a smooth sphere whose size and reflectivity are specified, the brightness of specularly reflected sunlight depends only on the observer's distance. For a sphere of 100-foot diameter and 90-percent reflectivity, the apparent magnitude is

$$m = -15.0 + 5 \log d,$$

where d is the distance in miles. Hence at a distance of 1,000 miles the Echo balloon should be magnitude 0.0; at 4,560 miles (the longest line-of-sight distance possible to a two-hour satellite) the magnitude is +3.3, apart from dimming caused by atmospheric extinction. Visual observers, therefore, will hardly need optical aids, except in determining accurate positions of the satellite, for which regular Moonwatch techniques should suffice.

Photographs may be obtained with almost any camera, and an f/3.5 lens of 3-inch focal length should register the satellite even when it is faintest. With larger equipment, photographers can perform a valuable service by taking timed exposures showing the disappearance or reappearance of the satellite from eclipse in the shadow of the earth.

The relation between the satellite's orbit and the shadow depends upon the date and hour of launching, not yet announced. However, consider a satellite at a height of 1,040 miles, entering the earth's shadow perpendicularly. It will take 10 seconds to traverse the penumbra and enter the umbra, not counting refraction. During the first nine seconds, the satellite would fade by only three magnitudes, but during the final second it would sharply dim into invisibility. The actual light curve will be greatly affected by refraction and extinction in the earth's atmosphere, and suitable observations of the phenomenon should be valuable for an understanding of these effects. The writer will appreciate receiving photographic negatives that record the satellite's brightness while it is entering or leaving the earth's shadow.

More About Explorer VII

TO COLLECT all the information telemetered to earth by an artificial satellite requires international co-operation. The National Aeronautics and Space Administration has recently offered to send telemetry codes and instructions to adequately equipped scientists around the world so that they can participate in the Explorer VII project. At present there are serious gaps in the chain of stations receiving the 20-megacycle signals from this satellite, which was launched last October 13th. Reports from the Soviet Union, China, central Africa, and the equatorial regions generally are especially needed.

Nevertheless, existing monitoring stations have obtained a vast amount of data. By the end of 1959, over 300 miles of magnetic tape had been used to record the information. The cost of tape alone came to $5,000 a month. Preliminary analysis of these records has already yielded important results.

Moving in an orbit inclined 50.3 degrees to the equator, the satellite's height currently ranges between 358 and 667 miles. Hence this probe traverses both the outer Van Allen radiation belt at high latitudes and the lower part of the inner belt at equatorial latitudes. Radiation measurements by Explorer VII confirm that the belts have a localized fine structure that varies with time.

On several occasions between October 16th and 20th, the satellite detected bursts of cosmic radiation, of uncertain cause, which seemed to originate between the Van Allen belts, about 13,000 miles from the earth's center. Probably these bursts were related to a geomagnetic storm that began on the 18th.

Other interesting events recorded were sudden decreases in cosmic ray intensity, each followed by a gradual recovery over several days. In one instance, the counting rate within Explorer VII dropped by about 60 per cent. While such decreases have been recorded at the earth's surface, they are much smaller there, amounting to about nine per cent in that case.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

Amateur Astronomers

THIS MONTH'S PROGRAMS

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. February 3, Dr. Theodore G. Mehlin, Williams College, "The Life Story of a Star."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. February 19, Dr. Bengt Strömgren, Institute for Advanced Studies, "Interstellar Matter."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. February 12, Dr. Frank B. Wood, Flower and Cook Observatory, "The Mount Stromlo Observatory and Southern Eclipsing Stars."

Pittsburgh, Pa.: Amateur Astronomers Association of Pittsburgh, 8:15 p.m., Buhl Planetarium. February 12, Dr. Joost de Jonge, Allegheny Observatory, "Projects in Elementary Astronomy for the Amateur."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. February 6, Dr. Otto G. Franz, U. S. Naval Observatory, "Galactic Clusters and Stellar Evolution."

SOCIETY LISTING

The April issue is tentatively scheduled to carry Here and There with Amateurs, the listing of all amateur groups that have registered with SKY AND TELESCOPE. Any changes in the previous listing, beginning on page 681 of the October, 1959, issue, should be sent to this magazine by February 15th. Clubs that were not included there and whose membership is open to the public should write for a registration blank.

AN AMATEUR'S OBSERVATORY DOWN UNDER

MY INTEREST in astronomy is only a few years old, yet I find it a most rewarding hobby. The observatory pictured here was originally built to house a 6-inch f/15 reflector, but I have since acquired a 10-inch f/4 Newtonian-Cassegrainian, with Dall-Kirkham optics made by R. Uquhart of Sydney. I constructed the telescope, which is motor driven in right ascension and declination, the electrical power being supplied by a 12-volt battery.

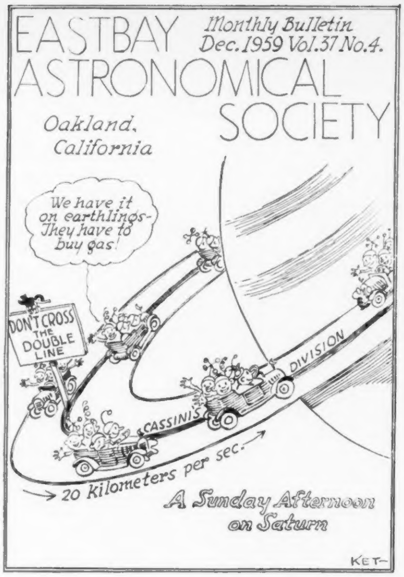
The observatory building is 13 feet in diameter, with side walls three feet high made of pressed hardboard sheeting lined with insulation. Felt carpeting covers the wooden floor. The reflector is mounted on a concrete pier sunk several feet into the ground.

Six months of week-end work and about $310 were needed to complete the dome. It is made of a framework of 2-by-1-inch timbers, cut and curved to the proper radius and covered with light aluminum sheets. Joint laps were waterproofed with caulking compound. The slit opening is 18 inches wide and extends past the zenith. Three grooved roller-race wheels running on a brass track enable the dome to rotate. The dome is light enough to be lifted on or off by two people, yet it has withstood winds of over 80 miles an hour. When not in use, it is anchored to the bottom wall with heavy clamps.

The building is painted white outside, and very little overheating is noticed. Three louvered window ventilators in the wall can be opened for quicker temperature stabilization.

I am a member of the Sydney Amateur Astronomical Society of Belfields and an associate member of the British Astronomical Society, Sydney.

ALLAN C. MARKS
17 Grove St.
Guildford, N. S. W.
Australia



This drawing by Frank Kettlewell of Saturn and its rings brightened a recent cover of the Eastbay Astronomical Society bulletin. Technically, the automobiles on the inner ring should be traveling in the same direction as those on the outer one.

SIOUX FALLS, SOUTH DAKOTA

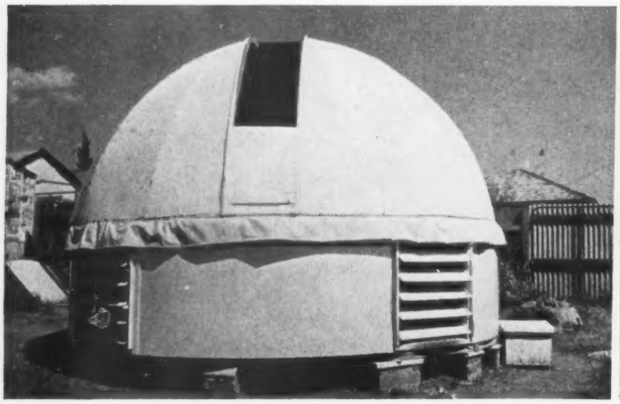
Nine amateurs have organized the Sioux Falls Amateur Astronomy Club. The secretary-treasurer is Dick Ness, 2305 Carter Place, Sioux Falls, S. D.

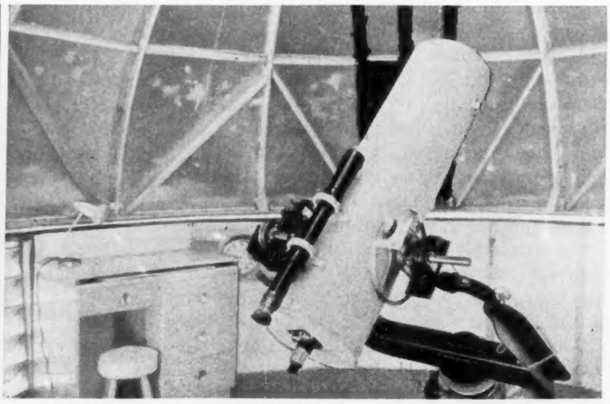
FARMINGDALE, NEW YORK

Weekly meetings of the newly formed Mid-Island Amateur Astronomers are held on Wednesday at 8 p.m. Interested amateurs are invited to contact John Ruel, 20 Yoakum Ave., Farmingdale, N. Y.

HAMPTON, VIRGINIA

There are 41 members in the newly formed Skywatchers Astronomy Club. Its president is Maxwell F. McNear, 123 Glenwood Rd., Hampton, Va.





Left: To keep out inclement weather, a skirt of heavy plastic material has been placed around the dome of this observatory in New South Wales, Australia. Right: A view inside the building. Both the right-ascension and declination circles on the 10-inch reflector have electric lights for easier reading.

GOTO OPT. CO.
Goto Optical is the oldest and largest maker of astronomical telescopes in Japan. Backed by our long experience and superior technical skill, we specialize in large-sized telescopes for both amateurs and professionals. We have recently gone into production on our planetariums, for which inquiries and orders have been received from all corners of the world.
GOTO'S 8-inch EQUATORIAL TELESCOPE
Objective
Focal length — 3,000 millimeters
Effective aperture — 200 millimeters
Magnifications
50x to 750x
GOTO TOKYO
Established in 1926, Japan's oldest and largest firm specializing in astronomical telescopes.
Catalogues will be sent upon request.
GOTO OPTICAL MFG. CO.
1-115 Shimmachi, Setagaya-ku, Tokyo, Japan
Cable Address:
GOTOPTIC TOKYO

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Observing Programs for the Lunar Eclipse in March

THIS YEAR three eclipses will offer interesting observing opportunities in the United States. There is a total eclipse of the moon on the night of March 12-13, another on the morning of September 5th, and a partial solar eclipse on the afternoon of September 20th. The first of these events is visible over the entire country, but the others will be unobservable from portions of the eastern states.

The passage of the moon through the earth's shadow takes place under favorable circumstances on March 12-13. For most of the Western Hemisphere, the entire sequence of events will be visible, from the first entry of the moon into the penumbra, through the partial stages and totality, until our satellite is once more entirely unobscured. Watchers who keep an all-night vigil will welcome the fact that the eclipse occurs on a Saturday night, and at a season when relatively comfortable observing temperatures can again be expected.

In the following timetable, adapted from the *American Ephemeris,* Central standard time (CST) is used. To convert to EST, add one hour; to obtain MST, subtract one hour; for PST, subtract two hours.

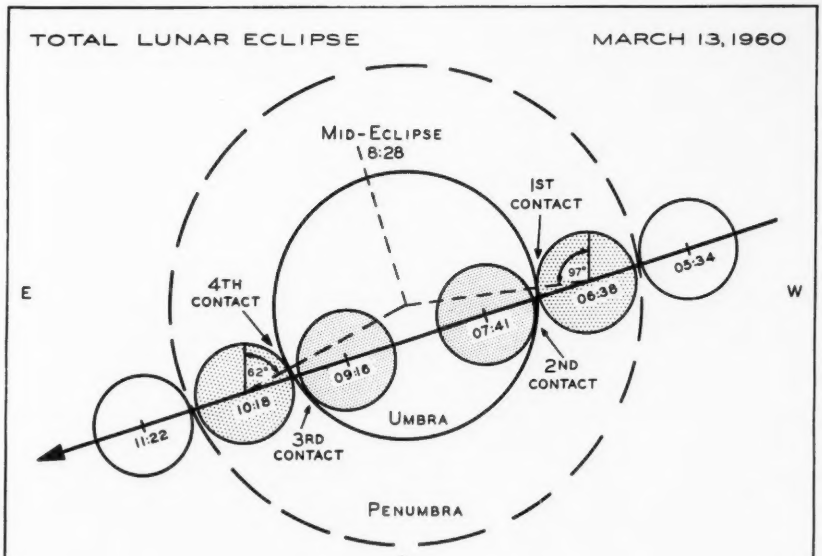
Moon enters penumbra	11:34 p.m.
Moon enters umbra	12:38 a.m.
Total eclipse begins	1:41 a.m.
Middle of the eclipse	2:28 a.m.
Total eclipse ends	3:16 a.m.
Moon leaves umbra	4:18 a.m.
Moon leaves penumbra	5:22 a.m.

For most observers, the first visible indication that an eclipse is in progress will come shortly before the second of the listed times, when a duskiness of the eastern portion of the lunar disk becomes evident. The outer, penumbral shadow of the earth produces no other appreciable effect. An imaginary spectator on the moon, if located at a point inside the penumbra, would see the sun only partly covered by the earth; if he is inside the central, umbral shadow, the sun would appear entirely covered.

For this reason, the umbral shadow is very much darker, and during totality the moon shines with a faint reddish or sooty color, from sunlight that has been refracted and scattered into the shadow cone by the earth's atmosphere.

As the diagram indicates, during the March eclipse the moon passes almost centrally through the earth's shadow, so totality will have a longer-than-average duration of 95 minutes. As a general rule, during totality all smaller detail on the moon becomes unrecognizable, and only the main seas and large craters may be detected. However, the darkness is much greater near the center of the shadow. Also, the deepness of the shadow differs considerably from one eclipse to the next. The smaller the telescope used, the brighter the totally eclipsed moon will appear, and it seems brighter still to the unaided eye.

Whether the amateur watches the eclipse simply for pleasure, or to carry out a systematic program of observations,



Positions of the moon at successive contacts as it passes through the earth's shadow, labeled in Universal time. This will be the first total eclipse of the moon visible from the United States since November 7, 1957.


ZEISS
Coudé
Refractor
150 mm
Quickly Adjustable
Ideal for college and private observatories
SPECIAL FEATURES
Due to the Coudé principle, position of the eyepiece is fixed—the observer never needs to change his seat.
For visual observation and photography. Photometers, spectographs and H-ALPHA monochromators available.
Continuous observation, without interruption in the hour angle.
Sun spot observation on projection screen without changing observer's position.
Focal length: 2250 mm. Magnification: 56—357x.
Price: $18,850.
Write for further information
CARL ZEISS, INC., 485 Fifth Ave., New York 17
CARL
ZEISS
West Germany

only modest equipment is needed. The unaided eye can follow the general course of events, and make valuable observations of the color of the eclipsed lunar disk, but binoculars are preferable. Best of all are small refractors or reflectors, with apertures of two to six inches. If your telescope is an 8-inch reflector or larger, stop down the aperture to about four inches, to minimize the dazzle of the uneclipsed part of the moon. Use your lowest-power eyepiece.

Many amateurs will wish to make their own photographic records of the eclipse. The size of the focal image of the moon obtained with a 6-inch f/8 reflector, for example, will be just under half an inch across. Projection of the image through a low-power eyepiece of good quality is a satisfactory method of obtaining a larger scale, at the cost of lengthened exposure. The photographic observer is cautioned to take experimental exposures of the moon with his chosen equipment well in advance of the eclipse.

During totality, the moon is so greatly dimmed that the effective exposure required is roughly 1,000 times greater than for the uneclipsed full moon. For satisfactory results during totality, the telescope should therefore be equipped with a clock drive. Additional information about photography of lunar eclipses is given by Peter A. Leavens' article on page 43 of the November, 1956, issue of SKY AND TELESCOPE (out of print).

For visual observers of the March 12-13 phenomenon, several programs of useful observations may be undertaken. The simplest ones are outlined first.

1. Darkness of the eclipse. There is a considerable range in the brightness of the moon at different eclipses, and it is desired to compare this event with previous ones. The French astronomer A. Danjon has suggested that this variation is correlated with solar activity. He used the following five-point scale of the luminosity L to classify eclipses:

$L = 0$: Very dark eclipse, moon almost invisible, especially in mid-totality.

$L = 1$: Dark eclipse, gray or brownish coloration, details distinguishable only with difficulty.

$L = 2$: Deep red or rust-colored eclipse, with a very dark central part in the shadow, outer edge of the umbra relatively bright.

$L = 3$: Brick-red eclipse, usually with a bright or yellow rim to the shadow.

$L = 4$: Very bright copper-red or orange eclipse, with a bluish very bright shadow rim.

The observation to be made consists in choosing the appropriate rating of the eclipse by the criteria above. For this purpose, the moon should be carefully examined shortly after totality begins,

and again at mid-totality, to assess both the marginal parts and core of the shadow. The naked eye, binoculars, or a small telescope may be used, but the observer should report the instrumental means, as this may have some influence on the rating.

2. Colors. Careful descriptions of the coloration of the moon during the course of the eclipse are of considerable interest. It is important that the time of each color observation be recorded, and also the optical means employed. The color phenomena may be more conspicuous to the unaided eye or in field glasses than in larger instruments.

3. Penumbra. During the partial stages of the eclipse, the dark umbral shadow will be seen to have a lighter, penumbral border. What are the first and last times during the eclipse when any penumbral darkening of the moon can be detected? Also, soon after the beginning of partial eclipse, try to estimate the width of the visible portion of the penumbra, as a fraction of the moon's diameter. The problem of the visibility of penumbral lunar eclipses was discussed on page 620 of the September, 1959, issue.

4. Enlargement of the umbra. At every lunar eclipse, the diameter of the earth's shadow is about two per cent larger than the geometry of the eclipse calls for. The amount of this enlargement is not the same from one eclipse to the next, for reasons not fully understood. It can be deduced from careful observations of the times when lunar craters enter the umbra or emerge from it.

At nearly all eclipses, during the partial stages the border of the umbra is definite enough so that such crater times can be noted to within a fraction of a minute. For a large crater, such as Plato, record when the shadow first reaches it and also the moment the crater is just covered; the average of these times tells when the crater was bisected. Times should be recorded to 0.1 minute, the correction of the clock or watch being known to this accuracy.

The times of any of the four contacts of the eclipse, if carefully observed, can also serve for the evaluation of the shadow enlargement. The writer will analyze any timings of craters or of contacts reported to Sky and Telescope.

The possibilities of interesting and useful observations are by no means limited to those mentioned above. For example, an amateur with photoelectric equipment can derive the light curve of some selected area of the moon throughout the eclipse, preferably using a color filter that isolates a well-defined spectral region. Records of the visibility of particular surface features during the eclipse are likewise valuable. In addition, all watchers of the event should be aware of the possibility of such rare occurrences as a zigzag outline to the

earth's shadow, or an eccentrically placed dark umbral core.

Serious observers who do carefully planned work under any of these headings during the March 12-13 eclipse are invited to send reports to SKY AND TELESCOPE, Harvard Observatory, Cambridge 38, Mass., for analysis and inclusion in a comprehensive summary. The report should clearly state the time and optical equipment used for each observation in the record, and should include details of sky conditions during the eclipse.

Amateur photographs of the eclipse, submitted for possible publication in SKY AND TELESCOPE (these will not be returned to the sender), should reach this magazine not later than Friday, March 25th. Only black-and-white prints, at least 4-by-5, are suitable for reproduction. The use of air mail special delivery is suggested for meeting the deadline.

J. A.

SUNSPOT NUMBERS

The following American sunspot numbers for November, 1959, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

November 1, 112; **2**, 89; **3**, 103; **4**, 92; **5**, 84; **6**, 111; **7**, 121; **8**, 144; **9**, 139; **10**, 141; **11**, 144; **12**, 146; **13**, 156; **14**, 164; **15**, 150; **16**, 129; **17**, 80; **18**, 67; **19**, 52; **20**, 71; **21**, 63; **22**, 88; **23**, 107; **24**, 155; **25**, 156; **26**, 147; **27**, 159; **28**, 172; **29**, 167; **30**, 161. Mean for November, 122.3.

Below are provisional mean relative sunspot numbers for December, 1959, by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations at Locarno and Arosa.

December 1, 142; **2**, 150; **3**, 171; **4**, 190; **5**, 126; **6**, 147; **7**, 136; **8**, 129; **9**, 94; **10**, 70; **11**, 82; **12**, 71; **13**, 59; **14**, 88; **15**, 123; **16**, 113; **17**, 107; **18**, 111; **19**, 114; **20**, 110; **21**, 103; **22**, 121; **23**, 106; **24**, 108; **25**, 110; **26**, 95; **27**, 132; **28**, 114; **29**, 135; **30**, 127; **31**, 153. Mean for December, 117.3.

HANDBOOK FOR OBSERVERS

THE HANDBOOK OF THE BRITISH ASTRONOMICAL ASSOCIATION 1960, *J. G. Porter*, editor, 1959, *British Astronomical Association*, 303 Bath Rd., Hounslow West, Middlesex, England. 70 pages. 5s for members, 9s for nonmembers; paper bound.

This is the 39th annual *Handbook* of the BAA, and contains the same kind of useful information as last year's, including occultation predictions for the eight stations in Great Britain, South Africa, Australia, and New Zealand.

To aid the amateur in planning his observing, there are ephemerides of the sun, moon, planets, periodic comets expected to return in 1960, and a convenient table of the sun's colongitude for lunar observers, with much other information. Predictions of the phenomena of Jupiter's satellites are given, together with charts for two of Saturn's moons, Titan and Iapetus. Detailed information on 1960's major meteor showers is provided.

ENGINEERED FOR THE LAST WORD IN BREATHTAKING PERFORMANCE . . . PRICED FOR FIRST CHOICE IN VALUE . . . FULLY EQUIPPED WITH MANY EXTRA FEATURES!

You'll marvel at how the superb optics of this portable RV-6

6-inch DYNASCOPE®

gives the same exquisite definition as far more expensive instruments!

including . . . • *Electric Drive (Patented)* • *Setting Circles* • *Rotating Rings*

A Complete Instrument, No Costly Accessories Needed!

Model RV-6 Complete with Dyn-O-Matic Electric Drive and All Features Described

$194.95

f.o.b. Hartford, Conn.
Shipping Wt. 55 lbs.
Express Charges Collect

This new addition to the Dynascope line has won immediate recognition from schools, colleges, and professionals, as an outstanding achievement in a 6-inch telescope. Although it was only recently introduced, our files are already filled with complimentary letters from excited amateurs and professionals all over the country. Each one is truly amazed at the superior optical performance of this new RV-6 6-inch Dynascope! Here is large aperture in a quality instrument at a price that compares with many 4-inch telescopes. *And this low cost includes such exclusive extra features as electric drive* (patented), *setting circles, and rotating rings!* There are no "extras" to run up your cost!

The superb optical system resolves difficult objects with definition that is absolutely breathtaking. The close tolerance of the precision construction assures an accuracy and smoothness of operation once associated only with the finest custom models. The heavy-duty mount, complete with electric drive, provides the stability so essential for satisfactory viewing, yet there is easy portability because in a matter of minutes the entire telescope can be dismantled into three easy-to-handle sections.

Only Criterion's engineering ingenuity, coupled with volume production and modern manufacturing methods, makes this handsome 6-inch model available at such reasonable cost. You can order it with complete confidence that it will live up to your expectations in every way, for this assurance is *guaranteed* under our full-refund warranty. Send your check or money order today. Or use our liberal time-payment plan and take months to pay.

ENJOY IT NOW — take up to 24 months to pay under our Easy Terms plan!

Just a small down payment delivers this big 6-inch DYNASCOPE. Pay the balance at your convenience over 6, 12, 18, or even 24 months! Write for details, or order today by sending your check or money order with coupon below.

You Could Pay $100 More Without Getting All These Superior Features (Except on Another Dynascope)

1. **EXQUISITE OPTICAL SYSTEM INCLUDES F/8 6-INCH PARABOLIC PYREX MIRROR** accurate to better than 1/8 wave, zircon-quartz coated, and guaranteed to reach all theoretical limits of resolution and definition. Teamed with elliptical diagonal, mounted in 4-vane adjustable spider.
2. **NEW DYN-O-MATIC ELECTRIC DRIVE** with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Entire drive housed in trim aluminum case. Plugs into ordinary household socket.
3. **CHOICE OF ANY 3 EYEPIECES** from the following: **65X**-18-mm. Achromatic Ramsden; **100X**-12.7-mm. Achromatic Ramsden; **150X**-9-mm. Achromatic Ramsden; **220X**-6-mm. Orthoscopic; **320X**-4-mm. Orthoscopic. All are precision-threaded, give sharp images to extreme edges.
4. **SOLID NEW EQUATORIAL MOUNT** extra-reinforced design to provide pillarlike stability. No annoying side play or wobble. Adjusts easily to any latitude.
5. **SETTING CIRCLES** for both right ascension and declination. Handsomely finished in fine aluminum.
6. **6 x 30 FINDERSCOPE, ACHROMATIC, COATED,** with accurate crosshairs and fine focus. Durable cast-aluminum bracket with 6 adjusting screws allows positive collimation.
7. **ROTATING RINGS FOR MAXIMUM VERSATILITY AND VIEWING COMFORT.** Solid-cast, chrome finish, rings are generous 1" wide with felt lining. Newly designed construction, with over-sized knurled adjusting knobs, affords maximum rigidity and allows for quick disassembly and portability, with or without tube.
8. **STRIKINGLY HANDSOME, WHITE, 50" BAKELITE TUBE** with porcelainized Duralite finish, durable yet light. Walls are 1/8" thick, completely insulated and anti-reflective blackened inside.
9. **BRASS RACK-AND-PINION EYEPIECE HOLDER** has precision-cut rack and gear for easier, smoother, more positive focusing. Takes standard 1¼" oculars, negative or positive.
10. **STRONG, VIBRATION-FREE, ALL-METAL TRIPOD** with easily removable legs. Provides sure, steady support, plus lightweight portability.

Sound too good to be true? Then read what these delighted DYNASCOPE owners have to say:

"I never dreamed such a brilliant, clear image could be had with a telescope costing under $200. It is one of these rare bargains that you find only once or twice in a lifetime." **B.S. — New Jersey**

"A friend of mine has a 6-inch telescope without electric drive, for which he paid over $300. He agrees that my new DYNASCOPE not only outperforms it, but is a much better-looking and better-built instrument." **J.L. — New York**

"Congratulations on the excellence of your workmanship. The optics are truly amazing. I never expected such wonderful performance." **L.H.N. — Massachusetts**

CRITERION MANUFACTURING CO.

331 Church St., Hartford 1, Conn.

Manufacturers of Quality Optical Instruments

Criterion Manufacturing Co.
Dept. STR-7, 331 Church St., Hartford 1, Conn.

☐ Please send me, under your MONEY-BACK guarantee, the RV-6, 6" Dynascope. Full payment of $194.95 is enclosed.

☐ Send complete information describing easy payment plans.

☐ Send FREE ILLUSTRATED LITERATURE of all the telescopes in the Dynascope line.

Name ....

Address ....

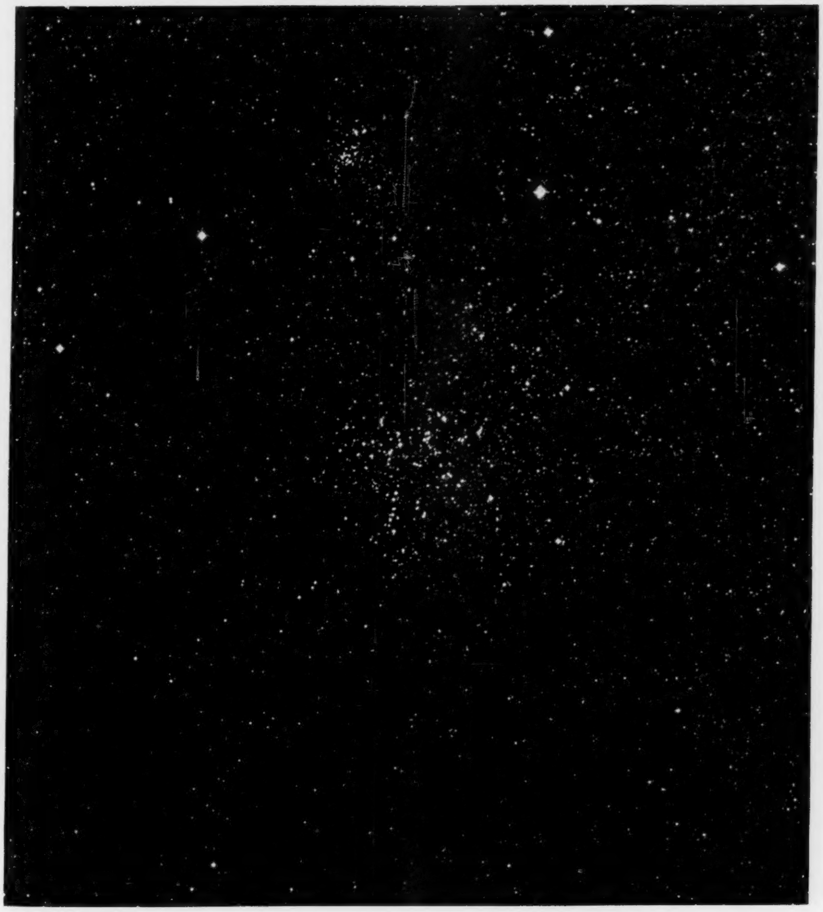
City .... **State** ....

Above, on a blue plate taken with Palomar Observatory's 48-inch Schmidt telescope, is the open cluster Messier 36, about 4,100 light-years distant from us. Below is another Auriga cluster, M37; though more distant, it is larger than M36. The width of the field of these illustrations is about 1⅓ degrees.

DEEP-SKY WONDERS

THREE of the brightest galactic clusters listed by Messier are in the constellation Auriga. All are at the threshold of naked-eye visibility, and the slightest optical aid will make them stand out as striking objects. They are M36, 37, and 38.

The first of these, M36 (NGC 1960), is the smallest, being 12′ in diameter and containing 60 stars. It is located at right



The large loose cluster in the middle of this Palomar Schmidt photograph is M38. Above it is the smaller cluster NGC 1907, only half a degree distant from the other. It was overlooked by Messier, though noted by his contemporary G. Legentil. South is upward on all three photographs with this article.

ascension 5h 32m.0, declination +34° 07′ (1950 co-ordinates), on the edge of the northern Milky Way inside the figure of Auriga. This cluster is rather open, that is, the stars are not impressively concentrated toward the center.

Most striking of the three is M37 (NGC 2099), at 5h 49m.0, +32° 33′. It is the brightest (visual magnitude 6.2) and has the most stars — 150, according to the Skalnate Pleso *Atlas Catalogue*. Whether your telescope is of the Moonwatch type or a large reflector, M37 is a treat. The view is further enhanced by the flickering background of the Milky Way.

M38 (NGC 1912) is the same size as M37, 20′ in diameter, but somewhat fainter, with only a hundred stars, though in a 10-inch telescope this figure seems far too conservative. The cluster is, however, usually visible to the naked eye without much effort. It is certainly far easier than M33 (the Triangulum galaxy), and probably easier than M11, the Scutum cluster. Located at 5h 23m.3, +35° 48′, M38 is well within the star-strewn Milky Way.

Photographs usually show a departure from circularity, a feature quite evident to visual observers. Older reports almost always mention a cross shape, which seems more pronounced with small instruments. A view with a 24-inch reflector on a fine Arizona night showed the cluster as irregular, and the host of stars made fruitless any effort to find a geometrical figure.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

BOOKS AND THE SKY

ELEMENTARY ASTRONOMY

Otto Struve, Beverly Lynds, and **Helen Pillans.** Oxford University Press, New York, 1959. 396 pages. $7.00.

THE senior author, Otto Struve, is widely recognized as a leader in astronomical research and as a writer of lucid articles for the amateur astronomer and layman. In his new endeavor, a text in elementary astronomy, he was assisted by Beverly Lynds and Helen Pillans.

In the preface the reader is informed that the book is not intended to replace the many excellent textbooks of descriptive astronomy now in use. Rather, "it is designed to meet the growing desire of students to derive from a course in astronomy a general background for the study of physical science." Its aim is to stress some of the main ideas of physics — such as gravitation, radiation, and heat — in relation to the universe. Less description, as well as less emphasis on philosophical and historical implications of the science, must accordingly be anticipated.

In brief, it is hoped that the student reader shall appreciate astronomy as an integral part of physics, and gain a sound working knowledge of basic physical science to provide a background for later specialization in some other branch of science or engineering. There is no presumption of previous training in mathematics or physics; calculus and trigonometry are omitted.

The book opens with a chapter entitled "The Universe," a beautifully written summary of everything from planets to continuous-creation theory. A student at the assumed level of preparation must accept most of the statements on faith, since complete understanding would presumably require that the bulk of the book had been thoroughly studied. This raises the question of the function of an introductory chapter. Is it to bewilder, astonish, intrigue? Or is it to form a connecting link between the reader's initial knowledge and background and the intellectual challenge that lies before him?

Chapter 2 is a review of fundamental units of length, mass, time, temperature, and the properties of the circle and sphere — all of which could have been placed in an appendix. A derivation of the stated number of square degrees on a sphere might have been included, as few elementary students have encountered this concept.

The next 12 chapters (150 pages, or about a third of the book) are devoted to the properties and characteristics of the solar system, exclusive of the sun. Here the reader is introduced, with varying degrees of detail, to matters of time, coordinates, gravitation, fundamentals of motion, Newton's laws, the earth's structure and motion, the moon, planets, satellites, comets, and meteors. The tone is strikingly different from the introductory chapter, and the reader is at once aware of the new approach to basic astronomy.

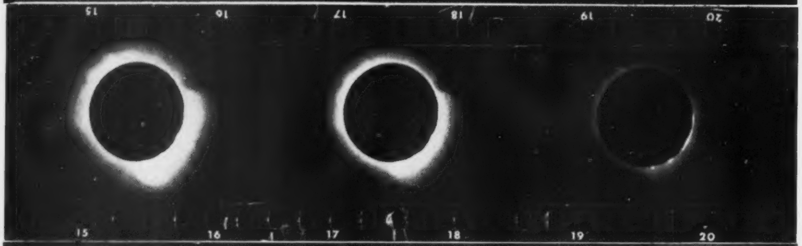
The authors have set themselves the task of giving "the beginning student as early as possible a good working knowledge of some of the basic ideas and theories of physical science. . . ." In the main they have accomplished this not by simple statements of physical laws and the corresponding mathematical formulas, but by actual use of these relations, as tools for the formulation of deductions and conclusions through the correlation of factual data. This text does not differ radically from many others in the extent to which physical law is stated, but it does differ in the extent to which direct application is made. Much that was formerly left to the discretion of the teacher is here developed step by step.

Although the mathematical tools are limited to arithmetic and algebra, the results, generally speaking, are more meaningful than simple numerical examples. Further understanding may be developed by the student through the solution of numerical problems propounded at the end of each chapter. Few discussion-type questions are offered. In all applications of physical laws, scrupulous attention is paid to the matter of units. The thoughtful student should thereby gain some appreciation of dimensional analysis.

In Chapter 4, the omission of an explicit definition of mass, in an otherwise detailed discussion of gravitation, is surprising, since in Chapter 32, "Relativity," the suggestion is made that this entity may be interpreted in several ways. In Chapter 6, on the motions of the earth, there occurs an abrupt and rather annoying change of topic, occasioned by the injection of an abbreviated treatment of the properties of light, the Doppler effect, and spectroscopy — to illustrate astronomical methods for determining the length of the astronomical unit.

Despite the emphasis placed on the role of radiation in physics and astronomy, students with little or no background in spectroscopy are placed at a definite disadvantage by the piecemeal treatment of this topic throughout the book. This points up clearly a difficulty recognized by those of us who must try to teach astronomy and several important aspects of physics simultaneously to students unfamiliar with either subject.

Chapters 15 to 19 deal with the sun. The discussion begins with an account of nuclear energy sources, treats atomic theory and spectroscopy, and ends with those aspects of the sun more commonly and readily observed. The theory of in-



QUESTAR GETS A LUCKY RIFT IN CLOUDS

Since cloudy skies obscured the solar eclipse of October 2, 1959, in many places and hampered most photographic efforts, we are publishing this picture of it because it shows more detail in the corona than any other we have seen so far.

We can only hope the engraver has heeded our note and by extra work has been able to capture on his plate some of the many coronal streamers and lines so plainly visible in the photograph. If this fails, or if the press is not in prime adjustment as this page gets printed, you have only our word for it that there was some interesting detail in the corona. Under the large picture we show three prints, in actual size, of the same negative, which indicate the size of Questar's prime image on the 35-mm. film. Each print was exposed a different number of seconds, which may help to show coronal structure.

The gentleman below is Mr. Dumont Rush, an American working in Belgium who took his brand-new Questar to the Canary Islands (he mentions Tenerife) for this October 2nd eclipse.

Mr. Rush says ruefully, "During totality I got no other pictures because of something I must have done wrong at the camera. More than likely I turned the shutter speed dial the wrong way in the dark, so my shutter speeds were far too fast. The enclosed shot, nearly at the end of totality, was made at 1/20 second on Adox KB-17 film. The focus seems bad. I found it very difficult to get sharp focus on an edge of light without features. Clouds covered the sun before the eclipse, which prevented me from trying to focus on sunspots."

Out of focus or not, it seems to us that Mr. Rush's single photograph is better than he thinks. We are pleased to note with what simplicity Mr. Rush has made an oil drum serve as good foundation for his equatorially mounted Questar. And we are pleased to have him say that "I find the Questar a joy to use and a joy to carry. For a small-aperture telescope it is very fine indeed and I am not in the least tempted by those amateurs who advertise for a Questar in exchange for some fully equipped larger glass."

We note that Mr. Rush has put a padded counterweight on the end of his Questar's star chart to balance the considerable weight of his M-3 Leica and its reflex housing. This is the right way to use a telescope when adding heavy auxiliary devices. Balancing the load relieves all working parts of strain and insures the smoothest motion when electric drive is used.

In designing Questar we tried to take full advantage of its very short tube, which overhangs the 4-inch bronze driving wheel by only a few inches instead of several feet. To make sure it cannot be overloaded, with consequent high tooth pressures, we build in a slipping clutch. To minimize friction, the drive wheel is faced with ultraslippery teflon. This is driven by a pinion gear whose torque exceeds 1,000 inch-ounces. No wonder Questar's drive is smooth and effortless!

The superfine Questar still costs only $995 postpaid. Each one is tested by us on the stars at night, and each comes in a beautiful velvet-lined fitted leather case made for us in Staffordshire, England. Extended payments are available and our 32-page illustrated booklet is yours upon request.

Questar

NEW HOPE · PENNSYLVANIA

ternal structure is presented in greater detail than is ordinarily found in comparable texts. As in the preceding chapters, elementary formulas and relations based upon them are used to arrive at essential conclusions.

Chapters 20 and 21 are on solar-terrestrial relations and the origin of the solar system. The latter chapter is one of the best accounts for elementary students to appear for some time. It is regrettable that appropriate literature references were not included for this and other topics in the text.

Stellar and galactic astronomy are discussed in Chapters 22 to 31 (133 pages, or another third of the book). Chapter 22, on stellar distances and luminosities, is essentially classical. Chapter 23, on the arrangement of stars in the Milky Way, seems out of order in the text. Reference is made in this chapter to interstellar absorption (Chapter 27), to various types of nebulae and novae (28), and to external galaxies (31). Similarly, in Chapter 24 on stellar motions, the discussion moves from galaxies to lesser structures in such a manner as to pose teaching difficulties. Chapter 25, "The Classification of Stars" (primarily spectroscopic), is excellently done.

In Chapter 26, "Star Clusters," and the succeeding treatment of current problems in astrophysics – stellar structure, evolution of stars, and interstellar matter – we find some of the superb writing that we have come to associate with Struve. While less reliance is placed on formulas and numerical substitution than in preceding sections, even the most inexperienced student can hardly fail to appreciate the magnitude of the problems man has attempted to solve in his efforts to understand the universe. The chapter on relativity is good, but the going will be rough for the student with little physics background. Telescopes and accessories are covered in the final chapter.

Star charts, printed in blue at the end of the book, are clear and usable in dim light. Each star has its Greek letter designation, but constellation boundaries are not included. The book is illustrated by 110 carefully chosen photographs, all excellently reproduced. In addition, there are 181 line drawings and one color plate of spectra. The placement of photograph captions leaves much to be desired, however.

A few inadequacies of expression were noted. On page 21 the caption states, "The differences in the star trails on these two photographs result from the earth's precessional motion." The chief difference in the plates lies in the variations in density of the star trails – the change in radii of the trails is so small as to pass unnoticed by the beginning student. The situation is clearly described 38 pages farther on in the text. On page 260 it is

Sky PUBLICATIONS for every astronomical interest

Norton's STAR ATLAS

This famous star atlas and reference handbook is particularly suited for amateurs and students who desire sky charts in book form. It covers the whole heavens, showing over 9,000 stars to magnitude 6⅓, nebulae, and clusters. There are descriptive lists of 500 interesting objects for viewing with small telescopes, and useful data are given for observers of the sun, moon, and planets. New 14th edition, 1959. **$5.25**

POPULAR STAR ATLAS

This compact, well-bound set of 16 maps is a simpler version of the Norton's *Star Atlas* described above. All stars down to magnitude 5½ are included. This edition is excellent for field use by constellation study groups and by meteor parties. **$2.00**

Elger's MAP OF THE MOON

The chart of the moon itself is 18 inches high by 17½ inches wide and identifies all the important lunar features. Below the map are notes by H. P. Wilkins on 146 of the more interesting areas. Printed on a sheet of paper 30 by 19½ inches and mounted on heavy canvas, the map is ideal for framing. **$3.00**

COLOR MAP OF THE NORTHERN HEAVENS

This is a large wall chart, 30 by 34½ inches, colorful as well as informative. The northern sky to −45° is shown on a polar projection, and each star is colored according to its spectral class. Stars brighter than magnitude 5.1 are included. The map is mailed unfolded in a heavy tube. **$1.50 each; 4 for $5.00**

COLOR CHARTS OF THE MOON

Two striking color charts of the first- and last-quarter moon were drawn by Joseph Klepesta, the well-known Czechoslovakian amateur astronomer. Each lunar half is an impressive 27 inches in diameter; the overall size of a chart, 23 inches wide by 33 inches high. Printed in predominantly gold and black on heavy paper, the charts are shipped unfolded in a cardboard tube. **$3.00 per set of 2**

MOON SETS

18 pictures, showing the entire visible face of the moon, are made from unsurpassed Lick Observatory negatives of the first and last quarters. Each halftone print is 8½ by 11¾ inches. Key charts supplied. **$3.00 per set**

LUNAR CRESCENT SETS

10 pictures are a matching series to Moon Sets, but for the waxing crescent 4½ days after new moon, and the waning crescent about five days before new moon. Four prints are close-ups of the waxing crescent, four of the waning; two show each crescent as a whole. Key charts included. **$2.50 per set**

SKY SETS I

24 pictures of objects in the solar system and in the Milky Way, all celestial wonders of interest and beauty. Each halftone print is 8½ by 11¾ inches. Separate sheet of captions included. **$4.00 per set**

SKY SETS II

24 pictures of nebulae in our galaxy, portraits of other galaxies, many made with the 200-inch telescope, and four drawings of the 200-inch telescope by Russell W. Porter. Sheet of captions included. **$4.00 per set**

LUNAR MAP. In two colors and over 10 inches in diameter. **25 cents each; 3 or more, 20 cents each**

SPLENDORS OF THE SKY. 36-page picture book of our neighbors, near and distant, in the universe. **75c**

RELATIVITY AND ITS ASTRONOMICAL IMPLICATIONS, by Dr. Philipp Frank. **75c**

HOW TO BUILD A QUARTZ MONOCHROMATOR for Observing Prominences on the Sun, by Richard B. Dunn. **50c**

THE STORY OF COSMIC RAYS, by Dr. W. F. G. Swann, Bartol Research Foundation. **75c**

An extraordinary addition to your library!

LAROUSSE ENCYCLOPEDIA OF ASTRONOMY

By Lucien Rudaux and G. de Vaucouleurs.

With an introduction by F. L. Whipple.

The long-awaited English translation of this monumental French volume — one of the most complete and best-illustrated compendiums of astronomy ever offered in one book.

A volume distinguished from all others by its detailed explanations, diagrams, and charts, designed for the reader who wants a thorough knowledge of the subject, yet has no previous introduction to astronomy. As a reference work it is unsurpassed, covering every facet of all phases of the science. Especially noteworthy are full-page color renditions of a map of the moon, a total lunar eclipse, Mars, Saturn, Jupiter, solar prominences, and 12 multiple star systems. Many of the beautiful photographs of celestial wonders are new to American readers.

The translation was made by the well-known British astronomers Michael Guest and John B. Sidgwick, and revised by Dr. Zdenek Kopal, professor of astronomy at the University of Manchester.

It contains 818 illustrations in 506 pages. Each page is 8 by 11⅛ inches.

Special introductory price, **$12.50**

Two Editions Available

ATLAS OF THE HEAVENS

ATLAS COELI 1950.0

These 16 charts by Antonin Becvar and his coworkers at the Skalnate Pleso Observatory, Czechoslovakia, cover the entire sky to stellar magnitude 7.75, showing double, multiple, and variable stars; novae, clusters, globulars, and planetaries; bright and dark nebulae; the Milky Way and constellation boundaries.

FIELD EDITION. Each chart is reduced from the original Atlas Coeli and is printed on heavy, stiff paper 18 by 12¼ inches. Stars are white on black background. Charts are shipped flat and unbound, 16 to a set. Ideal for outdoor observing and use at the telescope. **$4.00 each; 2 for $7.50**

DE LUXE EDITION. Printed in many colors, more than 35,000 celestial objects, including over 100 radio sources, are plotted. Bayer-letter and Flamsteed-number designations given. Transparent co-ordinate grid overlay included. The 16 charts are permanently bound in a heavy cloth cover, 16½ by 23 inches, with color chart key on a foldout flap. **$9.75**

ATLAS ECLIPTICALIS 1950.0

By Antonin Becvar

A bound set of 32 star charts, each 17½ by 24 inches, covers declinations between +30° and −30°, complete to magnitude 9.0, scale two centimeters per degree, epoch 1950.0. Spectral classes are shown by color. See page 161 of the January, 1959, issue for further description. Place your order with us and allow time for its transmission to the publisher in Czechoslovakia, from whom the atlas will be shipped directly to you. **$17.00**

MAKING YOUR OWN TELESCOPE

By Allyn J. Thompson. Tens of thousands of amateurs are using this basic book on telescope making. Here are complete step-by-step directions for making and mounting your own 6-inch reflecting telescope at low cost. This telescope can use magnifications up to 300 times. In easy-to-understand chapters, you will learn how to grind, polish, and figure the mirror, and how to make an equatorial mount that will provide a sturdy, solid support for your mirror.

211 pages, 104 illustrations (6th printing).... **$4.00**

THE HISTORY OF THE TELESCOPE

By Henry C. King. The first book to tell the full story of the evolution of the telescope. 456 pages, 196 illustrations, extensive references. **$7.50**

Spaceflight

Here is a popular yet authoritative magazine on rockets, astronautics, and space-travel astronomy, written especially for the layman, and edited by members of the British Interplanetary Society.

Spaceflight is printed during January, April, July, and October. Please specify the issue with which your subscription should start.

Subscription in United States and possessions, Canada, Mexico, and Central and South America: $2.50, four issues; $4.50, eight issues; $6.00, twelve issues. Single copy, 75 cents.

Write for descriptive catalogue. All items sent postpaid. Please enclose your check or money order.

SKY PUBLISHING CORPORATION

Harvard Observatory · Cambridge 38, Massachusetts

stated that in spectral class $G0$ the Ca II lines reach their maximum intensity. The diagram on the preceding page indicates that this state occurs at class $K0$.

The authors have in large measure attained their goals. This text will appeal especially to those students, either in formal class or in individual study, who seek an understanding of the methods as well as the conclusions of astronomical science. The teacher will find it useful either for a terminal course, or as a sound basis on which to build a more detailed treatment. The book might well have been titled *Elementary Astrophysics*.

R. WILLIAM SHAW
Cornell University

ASTRONOMICAL PHOTOGRAPHY AT THE TELESCOPE

Thomas Rackham. Macmillan Co., New York, 1959. 231 pages. $7.50.

THOSE familiar with astronomy and those knowing something about photography will find this book of great appeal. Assuming that the reader has some background in both hobbies, the author proceeds to develop the sport of astronomical photography in a very interesting manner.

Compared to the large number of books now available on telescope making, the amateur's references on astrophotography are limited to one or two volumes. Mr. Rackham's work is surely a welcome addition. On the whole it is authoritative and explicit.

He begins with a discussion of subjects within the reach of amateur cameras, giving briefly the characteristics of each object and an idea of what can be expected from the reader's labors. This is important, since the novice photographer is often quite disappointed with, for example, the tiny, fuzzy blobs that are his first planet images.

Mr. Rackham carefully notes that his book does not treat large-area sky photography, but is confined to solar, lunar, and planetary work, together with certain compact deep-sky subjects, such as nebulae and clusters. The recommendations for equipment, exposures, and films are generally those for solar system objects, and will be of value particularly to lunar and planetary observers.

The best feature of this text is that it is written by an amateur exclusively for amateurs. All too often books for the "6-inch f/8" astronomer are illustrated with discouragingly beautiful pictures of celestial objects taken with telescopes having apertures the size of the amateur's kitchen table! Mr. Rackham stays entirely within the capabilities of the small telescope, and all the photographs in this book were taken with his homemade 6-inch f/8 reflecting telescope.

Chapter 2 is a fine piece of scientific explanation. Many an amateur scientist is nearly ignorant of photographic principles, feeling that trial-and-error results are sufficient. The mysteries of photography – the relationships of exposure, density, speed, and contrast – are easily learned, providing an invaluable basis for using photography to best advantage. The short time spent reading the 20 pages on theory will be repaid many times in a firm knowledge of what happens in picture taking.

Some qualifications must be added to the author's statement, on page 34, that

when the focal length is doubled the exposure must be quadrupled, due to decreased image brightness. This is approximately true for extended surfaces, but not for stars. Poor seeing and the usual guiding errors will exaggerate the sizes of star images, thereby requiring longer exposures. For faint objects of either kind, reciprocity failure of the emulsion also calls for lengthened exposure times.

Telescopes and cameras are discussed in Chapters 3 and 4 in a manner interesting but at times confusing. Mr. Rackham speaks strongly on the merits of a reflector for photography, but he is somewhat optimistic in discounting coma in telescopes slower than f/3. This reviewer has found coma a great problem in using 35-mm. film at the prime focus of a 12-inch f/4.3 reflector. The average amateur, however, will have less trouble with the image aberrations of his 6-inch f/8 than he will with the British terminology used to describe mounting and camera parts.

Indeed, the English viewpoint is evident everywhere, especially in the detailed instructions on building a 35-mm. camera. It is probable that an American amateur will forsake construction of a camera, using instead an inexpensive second-hand camera body.

The moon is usually the first photographic target, and the author carefully distinguishes between photography of the full moon and the phases. Other writers have mentioned changes in exposure time required for different phases, but few add the important recommendation that the kind of film also be changed. Slow, high-contrast films (Kodak Microfile) yield fine results when the moon is full. But they have inadequate exposure latitude to handle the very high brightness range presented by the crescent phase, where slightly faster films of lower contrast (Kodak Panatomic-X) are preferred.

Mr. Rackham remarks that little is to be gained in enlarging the lunar image in the telescope when seeking maximum definition (page 121); he may be unduly influenced by his small telescope aperture or poor seeing. Certainly, with larger apertures and correspondingly shorter exposures, it is usually advantageous to record as large an image as possible, thereby minimizing the effects of grain and other losses in the emulsion. A microscope objective as an enlarging lens will often maintain high-quality images at long effective focal lengths.

The chapters on solar and planetary photography are informative and excellently illustrated. The photographs of the planets show honestly the capabilities and the limitations of the small telescope.

In the last chapters, there is a clear explanation of color filters, concluding with some good advice on darkroom operations. Good pictures are made not by expensive equipment but by careful technique and attention to detail. Dirt is the photographer's bugaboo, but proper washing, drying, and film handling help to minimize difficulties.

The appendix contains useful examples of calculations on exposure and image size, as well as more detail on specific film-developer combinations, the latter information needing some translation before it is of value to American amateurs.

The book contains no instructions regarding record keeping, a vital requirement in astrophotography. However, neither this nor other critical comments should detract greatly from a firm recommendation of this book.

GEORGE T. KEENE
Rochester Academy of Science

FIRST STEP TO FINER PERFORMANCE!

Easy, Low-Cost Way To Enjoy Thrills Of Astrophotography

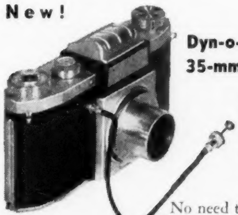
Convert your present 35-mm. camera with this new adapter

Developed by Criterion especially for single-reflex 35-mm. cameras with interchangeable lens. Simply remove present lens mount and add this precision-made achromatic lens that adapts camera to eyepiece of any telescope — refractor or reflector. When ordering, *be sure to specify make of your camera.*

For 35-mm. cameras with SCREW-TYPE lens mount
Cat. #CPA-36 for 1¼" eyepiece holders.. **$19.00**
Cat. #CPA-37 for 4" standard Dynascopes **$17.50**

For 35-mm. cameras with BAYONET-TYPE lens mount
Cat. #BPA-36 for 1¼" eyepiece holders.. **$22.50**
Cat. #BPA-37 for 4" standard Dynascopes **$21.00**

New!



Dyn-o-Astro 35-mm. Camera

at less than regular price of camera alone!

No need to be an expert photographer to take exciting astrophotos with this *single-reflex*-type, precision-made 35-mm. camera. No complicated settings. No plates or filmholders to load and unload. No worries about missing target. Large focusing screen shows you *exactly* what you are shooting, right up to moment you take the picture. Includes such advanced features as:

- No accidental double exposures. Winding knob automatically advances film, positions mirror, winds shutter, counts exposures.
- Dual-speed setting knob controls both fast and slow shutter speeds. Color coding makes mistakes impossible.
- Integrated magnifier for critical focusing even on dim objects.

Takes time exposures and also has speeds up to 1/500 second. Guaranteed for 2 years. Complete, ready for use.

Model CP-35 fits 1¼" eyepiece holder **$89.00 postpaid**
Model CP-36 fits all standard 4" Dynascopes **$85.00 postpaid**

Dyn-o-Swing Camera Support

fits any 4" or 6" telescope without drilling!

Takes guesswork out of astrophotography by providing *precise centering* of camera over eyepiece. Smooth rack-and-pinion adjustment. Easily attached or detached from tube, with rigid clamp for maximum stability. Special arm lets you swing camera away from eyepiece for visual observation, with instant return for photographing. Can be used with almost any camera. Postpaid.

Cat. #CS-4 to fit all 4" Dynascopes.......**$17.50**
Cat. #CS-47 to fit all 4¾" O.D. tubes..**$18.95**
Cat. #CS-67 to fit custom 6" Dynascope and 7¼" O.D. tubes.......... **$19.95**

Catalog F, describing other accessories and parts, cheerfully sent on request. Satisfaction guaranteed, or money refunded. All items sent postpaid. We pay all postage costs. No shipping, crating or packing charges. Send check, cash, or money order for immediate delivery.

Paraboloidal Mirrors

The most important part of a reflector telescope is the precisely figured mirror. A mirror with a spherical surface suffers from spherical aberration, so it must be altered to a paraboloid to focus all the light rays in each bundle to the same point. Considerable skill is required to parabolize a fine mirror properly. Criterion Custom mirrors are made of the best pyrex glass, selected for freedom from internal stress and strain, and of the correct thickness for each size, parabolized by craftsmen and tested by Ronchi and Foucault tests, as well as by diffraction rings and resolution of double stars. They are aluminized and overlaid with zircon quartz. Each is guaranteed unconditionally, and to perform to the limit of resolution for its size.

4" pyrex, f.l. approx. 40"	**$31.00**
6" pyrex, f.l. approx. 54"	**$45.00**
8" pyrex, f.l. approx. 64"	**$89.00**
10" pyrex, f.l. approx. 80"	**$179.00**
12" pyrex, f.l. approx. 96"	**$275.00**

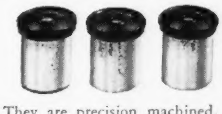
A tolerance of 5% in focal length is customary. A deposit of ⅓ is required with orders for 8" to 12" mirrors.

Reflecting Telescope Mirror Mounts

Mounting the mirror to your scope correctly is most important. Criterion mounts are especially well designed, and are made of cast aluminum with brass mounting and adjustment screws. One section fits tube, other section holds mirror. Alignment accomplished by three spring-loaded knurled adjusting nuts. Outer cell designed to fit into or over your tube. Sufficient space left between the two cells. All drilled and tapped. Complete with holding clamps, springs, nuts, etc. Ready for use. Will prevent vibration and hold alignment once set. Will hold mirror without distortion of surface figure.

3"	**$3.00**	6"	**$6.00**
4"	**3.50**	8"	**12.50**
5"	**4.00**	10"	**14.75**

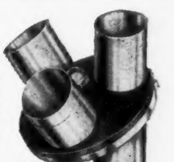
Complete Eyepieces



Finest quality. They are precision machined, mounted in standard 1¼" outside diameter barrels; ⅞" O.D. also available at no extra cost. Can be taken apart for cleaning. Designed to give sharp flat field clear to edge.

Huygens 18-mm. f.l. (¾")	**$ 7.50**
Kellner 9-mm. f.l. (⅜")	**7.90**
Kellner 7-mm. f.l. (9/32")	**8.50**
Kellner 12.7-mm. f.l. (½")	**9.50**
Orthoscopic 6-mm. f.l. (¼")	**12.50**
Orthoscopic 4-mm. f.l. (5/32")	**14.50**

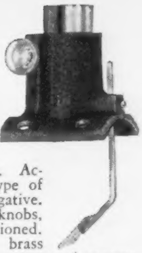
Revolving Turret



The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

Cat. #SRT-350.......... **$14.50**

Rack-and-Pinion Eyepiece Mount



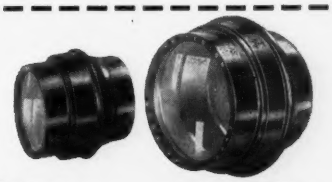
The most mechanically perfect focusing is by rack and pinion. This mount takes standard 1¼" eyepieces. Full 3½" of travel — more than ever before. Accommodates almost any type of eyepiece — positive and negative. Two knurled focusing knobs, variably tensioned and positioned. Solid cast-metal sliding brass tube — close tolerance prevents looseness. Mount aligns itself to any type tube. Four mounting holes, nuts and bolts included. Eye mount has square-rod-type diagonal holder which prevents loose alignment and vibration. Rod tempered to minimize temperature changes. Adjustable for 3" to 8" scopes, also 12" scopes if so specified at no extra cost. Order one or more of the complete eyepieces described below at the same time you send for this rack-and-pinion device, which accommodates any of our eyepieces perfectly.

Cat. #SU-38 **$7.95 postpaid**

New Model Eyepiece Mount

Same features as above but has wider base that is contoured to match the curve of a 7" to 8" diameter tube. Makes professional appearance. Furnished without Diagonal Rod #SU-9R **$9.95**

Diagonal Rod — Cat. #SU-9R........**$1.00**



Custom Achromatic Objectives and Sunshade

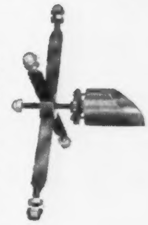
Criterion Custom Series Achromatic Objectives are of the highest precision quality, tested and approved and acclaimed to be superb in every respect. Equipped with sunshade and dewcap.

FEATURES

- Perfect color correction at the wave lengths of the C and F spectral lines, best for visual observing. Scientifically designed, corrected by master craftsmen.
- Delicately hand-corrected to fullest minimization of residuals, and to eliminate spherical aberration.
- Air-spaced to very critical optical formula.
- Magnesium-fluoride coated on all surfaces for maximum light transmission.
- Cell engraved with effective focal length and completely threaded.
- Sunshade extension with dewcap on all sizes.

Cat. #	Clear Aperture	Focal Length	Price
S-210	60 mm. (2.4")	910 mm. (35.8")	**$19.95**
S-220	3"	1250 mm. (49.2")	**52.00**
S-230	4"	1600 mm. (62.9")	**95.00**

Four-Vane Diagonal Holders



Criterion 4-vane diagonal mountings are fully adjustable, will hold elliptical diagonals in perfect alignment. Made of brass, chemically blackened. Precision adjusting screws center flat and vary its angle so that primary and secondary mirrors can be set in perfect alignment. Thin vanes with special adjustable studs.

Cat. #	Minor-Axis Size	For Tubes	Price
S-51	1.25"	6½" to 7½"	**$10.00**
S-52	1.30"	6½" to 7½"	**10.00**
S-53	1.50"	8½" to 9½"	**10.00**
S-54	1.75"	9½" to 10½"	**12.50**
S-55	2.00"	11" to 11½"	**14.95**
S-56	2.50"	Specify tube I.D.	**19.95**

CRITERION MANUFACTURING CO.

Manufacturers of Quality Optical Instruments

Dept. STP-21, 331 Church St., Hartford 1, Conn.

See the back cover.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A 20-INCH REFLECTOR BUILT IN BRAZIL — I

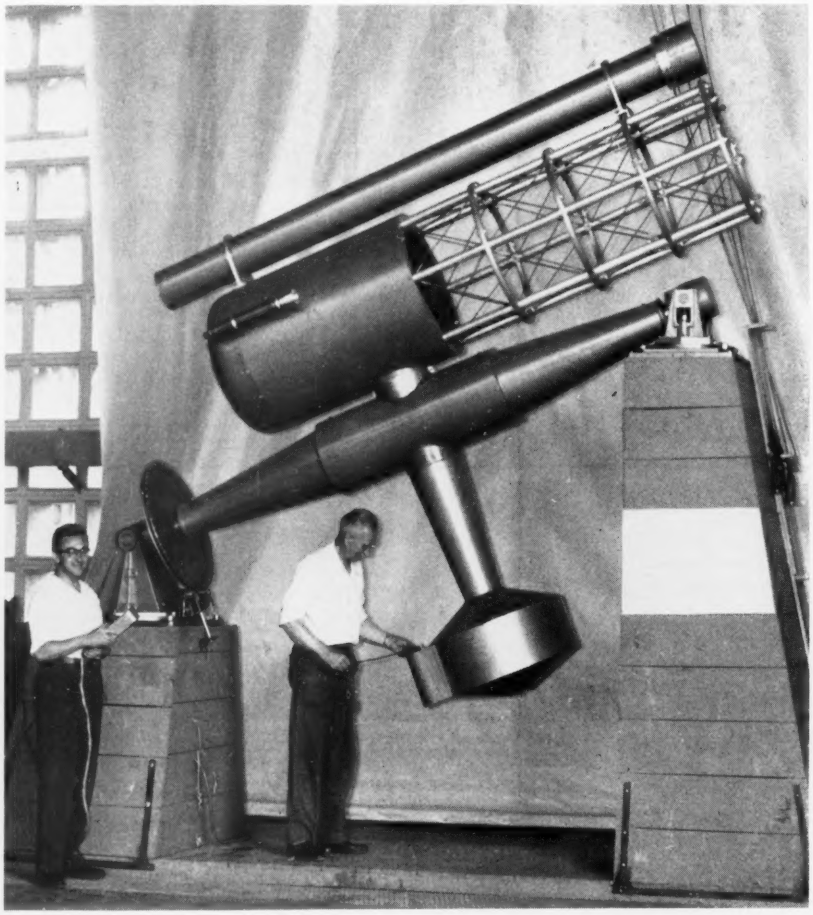
FOUR YEARS of intensive work were required to complete the largest telescope in Brazil, a 20-inch Newtonian-Cassegrainian reflector. So far as I know, it may be the largest astronomical instrument built entirely in South America.

This reflector, pictured below with the 8-inch refractor that is its guiding telescope, has been installed in Sao Jose dos Campos, at the Centro Tecnico de Aeronautica. Another identical reflector was made at the same time, being my property and at present in storage in California.

Actually, I am neither an astronomer nor a professional telescope maker, but a mechanical and aeronautical engineer whose hobby is the kinematic design of precision instruments. More than 20 years ago, I was acquainted with the late Russell W. Porter at California Institute of Technology, where he was working on the 200-inch Hale telescope project. This aroused my interest, and eventually led to the design of the 20-inch instrument.

During this very extended undertaking, I was greatly aided by Abram Szulc, who did almost all of the optical work. The primary mirror is f/6, giving a Newtonian focal length of 120", but as a Cassegrainian it is 480", or f/24. Before these specifications were finally adopted, design studies were made of 56 optical combinations, covering eight Newtonian f-ratios and seven Cassegrainian amplifications. The primary and secondary mirrors, as well as the Newtonian diagonal, were made of pyrex glass.

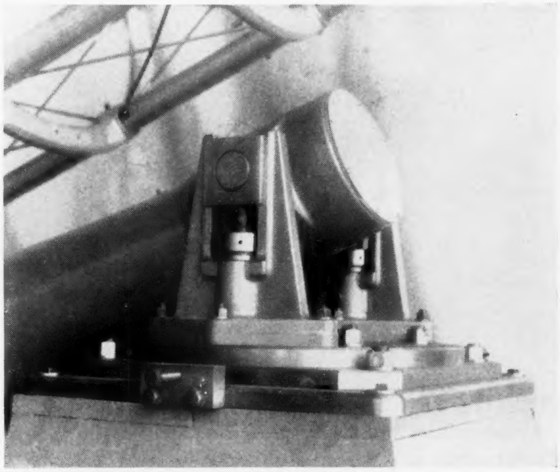
Mounted piggyback on the Brazilian reflector's tube, the 8-inch refractor is a sizable telescope in its own right. It has



In the workshop, temporary wooden piers were erected for assembling the 20-inch Bradley Young reflector and its 8-inch guiding telescope (top). Still to be installed when this picture was made were the eyepiece assemblies, the Newtonian diagonal, and the Cassegrainian secondary's mounting. At the left, Abram Szulc holds the six-button control box, while in the center a shop assistant works on the declination drive motor. This view is toward the west side of the mounting, the south polar axis support being elevated. All illustrations with this article were supplied by the author.

a two-element achromatic objective, made from heavy crown and dense flint glass manufactured by the English firm of Chance Brothers, Ltd. The focal length is 128″, corresponding to f/16.

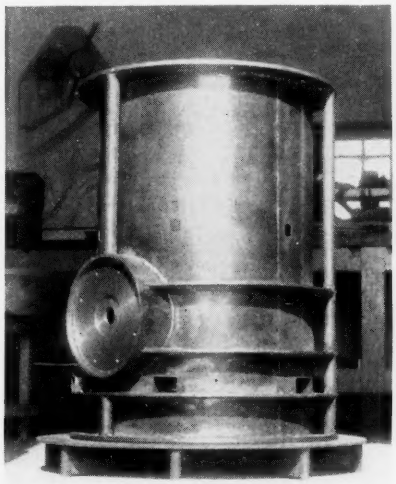
After preliminary design studies were made of six different mountings, followed by detailed analyses of two of these, a two-pier English-type equatorial was chosen. It has the great advantage of permitting uninterrupted observing of an object while it passes across the meridian, and hence is very convenient for long-exposure astronomical photography.



Orientation of the polar axis is accomplished with this assembly at the south bearing. The round capstan nut in the vertical yoke casting, together with its companion on the far side of the axle, control the elevation of the polar axis by acting on the heavy vertical screws. Azimuth can be changed by turning the bolt just above the base plate (lower left).

The polar axle, however, must be especially rigid. Here it is made of $\frac{1}{8}''$ welded steel sheet with $\frac{1}{2}''$ internal bulkhead rings, a large central section being fitted into tapered end portions. For even greater rigidity, this construction is reinforced by an inner seamless steel tube $4\frac{1}{2}''$ in diameter, with a 3/16″ wall thickness.

At the bearing position at each end of the polar axis, a quill shaft of forged steel, machined all over, was pressed into the inner $4\frac{1}{2}''$ tube. The rotation at each end is on two 7″ ball bearings carried in a cast-steel case, which is mounted in a heavy trunnion fitting. The south (upper) trunnion has provision for convenient alignment of the polar axis in azimuth and elevation.



The central barrel of the lower part of the telescope tube is seen here before the welding of the outside cover sheets. At the lower left is the plate for attachment to the declination-axis assembly. The mirror-cell position is at the top.

The declination-axis assembly is of similar construction to the polar axis, with a $4\frac{1}{2}''$-diameter seamless steel tube. Radial loads on the upper end are carried by a roller bearing over 9″ in diameter, and axial loads are borne by a 7″ ball bearing at each end of the declination axle.

A conical steel housing joins the polar-axis housing to the large steel plate on which the declination driving mechanism and declination counterweights are mounted. A steel casting bolts into the plate in the barrel of the main tube and joins it to the polar-axis housing.

To insure stability, the main lower portion of the reflector's tube is a double-walled cylinder of 3/32″ welded steel, with five internal bulkhead rings of $\frac{1}{4}''$ and $\frac{1}{2}''$ steel plate. The front skeleton extension has six duralumin tubes, each 2″ in diameter with a wall thickness of $\frac{1}{8}''$. The four cast-aluminum rings are 17″ apart, with diagonal bracings of 3/16″ stranded-steel aircraft cable.

The telescope is driven in right ascension by means of a special 360-tooth bronze worm wheel about 30″ in diameter, mounted just in front of the north bearing of the polar axis. The worm, 1.875″ in diameter, is supported on two double ball bearings, in a mounting that is hinged against the trunnion housing, as illustrated on page 251. Two springs support the mounting and force it into contact with the worm gear in such a manner as to eliminate all backlash.

Three independently controlled reversible electric motors of 1/10 horsepower operate the right-ascension motions, one for tracking, one for slow motion, and one for slewing rapidly to any part of the sky. The motors and associated gear

Mounted in ALUMINUM CELLS

AIRSPACED OBJECTIVES

We can supply ALUMINUM TUBING

MOUNTED AIR-SPACED TELESCOPE OBJECTIVES

3¼" (clear) DIAMETER

f/15—48" focal length { UNCOATED .... $28.00 / COATED 32.00

4⅛" (clear) DIAMETER

f/15—62" focal length { UNCOATED .... $60.00 / COATED 69.00

"THOSE WHO KNOW" BUY FROM US BECAUSE: Each lens is thoroughly tested and guaranteed to resolve to Dawes' limit. They are corrected for the C and F lines (secondary chromatic aberration). The zonal spherical aberration and the chromatic variation of spherical aberration are negligible. The cells are machined to close tolerances so that they fit directly over or into our standard aluminum tubing, eliminating any mounting problems. Test a lens, or have any qualified person test it; we are certain that you will be satisfied. If not, take advantage of our money-back guarantee. *We offer the lowest priced, hand-corrected, precision, American-made astronomical objective,* mounted in an aluminum cell. Our reputation for high-quality lenses has established us as the most reliable source in the industry.

NEW! 6" LENSES

AIR-SPACED TELESCOPE OBJECTIVES

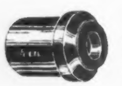
6" (clear) DIAMETER

Hard-coated on 4 surfaces

f/10—60" focal length { MOUNTED .... $175.00 / UNMOUNTED 150.00

f/15—90" focal length { MOUNTED .... $175.00 / UNMOUNTED 150.00

Mounted Eyepieces



The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black-anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
6 mm. (¼")	Ramsden	$ 4.75
12.5 mm. (½")	Ramsden	4.50
12.5 mm. (½")	Symmetrical	6.00
16 mm. (⅝")	Erfle (wide-angle)	12.50
16 mm. (⅝")	Triplet	12.50
18 mm. (¾")	Symmetrical	6.00
22 mm. (27/32")	Kellner	6.00
27 mm. (1-1/16")	Kellner	4.50
32 mm. (1¼")	Orthoscopic	12.50
35 mm. (1⅜")	Symmetrical	8.00
55 mm. (2-3/16")	Kellner	6.00
56 mm. (2¼")	Symmetrical	6.00

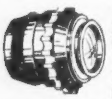
COATED LENSES 75 cents extra.

"Giant" Wide-Angle Eyepieces

ERFLE EYEPIECE (65° field) contains 3 coated achromats. 1½" E.F.L., clear aperture 2⅛". Has a focusing mount with diopter scale. Will make an excellent 35-mm. Kodachrome viewer. Magnifies seven times .... **$12.50 ppd.**

Same as above without diopter scale **$9.95**

1¼"-diam. Adapter for eyepiece above **$3.95**



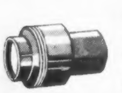
WIDE-ANGLE ERFLE (68° field) **EYEPIECE.** Brand new; coated 1¼" E.F.L. Focusing mount. 3 perfect achromats, 1-13/16" aperture **$13.50**

1¼"-diam. Adapter for eyepiece above **$3.95**

WIDE-ANGLE ERFLE 1½" E.F.L. Brand new; contains Eastman Kodak's rare-earth glasses; aperture 2"; focusing mounts; 65° field **$22.50**

1¼"-diam. Adapter for eyepiece above **$3.95**

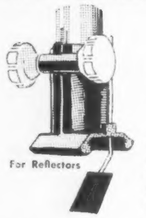
An Economical Eyepiece



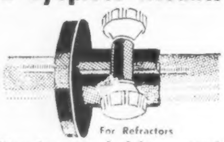
This mounted eyepiece has two magnesium-fluoride coated lenses 29 mm. in diameter. It is designed to give good eye relief. E.F.L., 1¼". Cell fits 1¼" tube.

Coated **$5.90 ppd.** Not coated **$5.25 ppd.**

Rack-&-Pinion Eyepiece Mounts



For Reflectors



For Refractors

Here is a wonderful opportunity for you to own a most mechanically perfect Rack-&-Pinion Focusing Eyepiece Mount with variable tension and adjustment. Will accommodate a standard 1¼" eyepiece, positive or negative. The body casting is made of lightweight aluminum with black-crackle paint finish, focusing tube of chrome-plated brass. Focusing tube for refractors has a travel of 4", for reflectors 2", and will fit all size tubing.

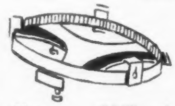
REFRACTOR TYPE for 2⅛" I.D. Tubing **$12.95 ppd.**
" " for 3¼" I.D. Tubing **12.95 ppd.**
" " for 4⅜" I.D. Tubing **12.95 ppd.**
REFLECTOR TYPE (less diagonal holder) **8.50 ppd.**
DIAGONAL HOLDER .... **1.00 ppd.**

Astronomical Mirrors

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon-monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	$ 9.75
Pyrex	4¼"	45"	13.50
Pyrex	6"	60"	25.00

Mirror Mount



Cast aluminum. Holds all our mirrors firmly with metal clips. Completely adjustable. Assembled.

3-3/16" Mount fits our 4½" tubing .... **$4.00 ppd.**
4¼" Mount fits our 5" tubing .... **4.00 ppd.**
6" Mount fits our 7" tubing .... **6.50 ppd.**

GIANT "3" inch TELESCOPE

HIGH-POWER SCOPE AMERICAN MADE

40 POWER

ALL LENSES COATED

Big 3"-diameter, achromatic, coated objective will give you the brightest crystal-clear images. Micrometer spiral focusing drawtube, lightweight aluminum construction throughout, tough black crackle finish. Length open 22", closed 15½". Upright image. Guaranteed to perform flawlessly. **$57.50 ppd.**

TRIPOD FOR TELESCOPE ABOVE
Sturdy, lightweight, all-metal, black crackle finished tripod. Ball-swivel joint allows easy directional adjustments. Equipped with a standard ¼ x 20 stud which will fit any photo tripod. Stands 11" high, weight 1½ lbs. Comes with web straps. **$8.95 ppd.**

Special Coated Objective

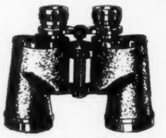
BIG 2⅛" DIAM. — 40" F.L. — $6.00

These achromatic objective lenses are tested and have the same high quality as "Big Lenses" described below, except they are seconds for slight edge chips or small scratches only. Quality guaranteed. **ONLY $6.00 ppd.**

Coated Binoculars

Beautifully styled imported binoculars. Precision made.

LOW, LOW PRICES!



American Type

"Zeiss" Type

Complete with carrying case and straps. American type offers a superior one-piece frame and clean design.

Size	Field at 1,000 yards	Type	Center Focus	Ind. Focus
6 x 15	360 ft.	Opera	—	$12.75
6 x 30	395	"Zeiss"	$18.75	16.75
7 x 35	341	"Zeiss"	20.75	17.95
7 x 35	341	American	23.50	—
7 x 35	578	Wide-Angle 11°	35.00	—
7 x 50	372	"Zeiss"	24.95	22.50
7 x 50	372	American	32.50	—
8 x 30	393	"Zeiss"	21.00	18.25
10 x 50	275	"Zeiss"	28.75	26.75
20 x 50	183	"Zeiss"	33.75	31.75

All prices above plus 10% Federal tax.

Monoculars

Brand new, coated optics, complete with pigskin case and neck straps.

	Price		Price
6 x 30	$10.00	7 x 50	$14.75
8 x 30	11.25	16 x 50	17.50
7 x 35	12.50	20 x 50	20.00

8-Power Elbow Telescope

8 x 50

This M-17 telescope has a brilliant-image 48° apparent field — 325 feet at 1,000 yards. The telescope can be adjusted for focusing 15 feet to infinity. It has a 2" objective, focusing eyepiece 28-mm. focal length with an Amici erecting system. Turret-mounted filters: clear, red, amber, and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Gov't. cost $200.

Not coated **$13.50 ppd.** Coated **$17.50 ppd.**

"BIG" ACHROMATIC TELESCOPE OBJECTIVES

We have the largest selection of diameters and focal lengths in the United States available for immediate delivery. These are perfect magnesium-fluoride coated and cemented Gov't. surplus lenses made of finest crown and flint optical glass. Not mounted. Fully corrected. Tremendous resolving power.

● We can supply ALUMINUM TUBING AND CELLS for the lenses below. ●

Diameter	Focal Length	Each
54 mm. (2⅛")	254 mm. (10")	$12.50
54 mm. (2⅛")	300 mm. (11.8")	12.50
54 mm. (2⅛")	330 mm. (13")	12.50
54 mm. (2⅛")	390 mm. (15.4")	9.75
54 mm. (2⅛")	508 mm. (20")	12.50
54 mm. (2⅛")	600 mm. (23½")	12.50
54 mm. (2⅛")	762 mm. (30")	12.50
54 mm. (2⅛")	1016 mm. (40")	12.50
54 mm. (2⅛")	1270 mm. (50")	12.50
78 mm. (3-1/16")	381 mm. (15")	21.00
80 mm. (3⅛")	495 mm. (19½")	28.00
81 mm. (3-3/16")	622 mm. (24½")	22.50

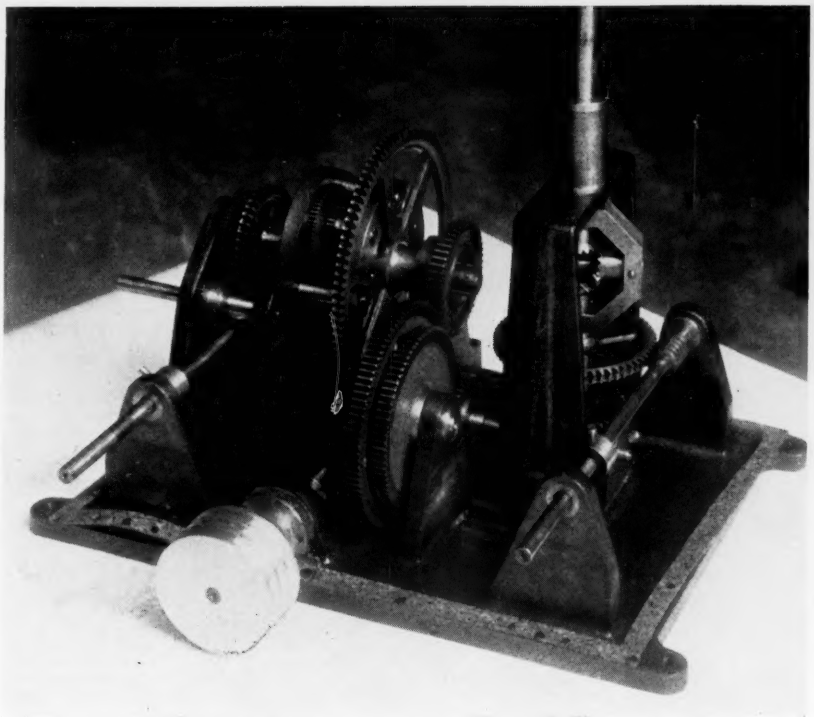
Diameter	Focal Length	Each
83 mm. (3¼")	660 mm. (26")	$28.00
83 mm. (3¼")	711 mm. (28")	28.00
83 mm. (3¼")	762 mm. (30")	28.00
83 mm. (3¼")	876 mm. (34½")	28.00
83 mm. (3¼")	1016 mm. (40")	30.00
102 mm. (4")	876 mm. (34½")	60.00
108 mm. (4¼")	914 mm. (36")	60.00
110 mm. (4⅜")*	1069 mm. (42-1/16")	60.00
110 mm. (4⅜")	1069 mm. (42-1/16")	67.00
128 mm. (5-1/16")*	628 mm. (24¾")	75.00
128 mm. (5-1/16")	628 mm. (24¾")	85.00

*Not coated

● **FREE CATALOG** ●
"MILLIONS" of lenses, prisms, eyepieces, mirrors, binoculars, telescopes, parts and accessories. Write today.

A. JAEGERS
691 S Merrick Road
LYNBROOK, N. Y.

We pay the POSTAGE in U.S. — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise is returned within 30 days.



Through this compact gear train, sidereal motion is transmitted to the telescope, as well as fast-setting and slow motions in right ascension.

box are mounted together on a tray placed within the concrete pier supporting the north end of the instrument.

The tracking drive motor is double-ended, with one side connected directly to the input shaft of the gear train. The opposite end carries a flywheel with an adjustable moment of inertia. With this, the motor can be controlled to run at exactly 1,600 revolutions per minute by a master-slave pair of synchrone-type pendulum clocks. Alternate and optional operation is also available through a temperature-controlled quartz oscillator clock, the crystal frequency being 12 kilocycles per second. This is reduced through a series of multivibrator stages to give two control outputs, of 60 cycles and one cycle per second, respectively.

Both the quartz oscillator and the synchrone clock run on mean solar time, a four-gear conversion train producing sidereal time within approximately 0.02-second-per-day error. A listing by Alan Gee of standard stock gears providing such corrections can be found in *Amateur Telescope Making — Book II,* page 322.

The photograph shows the combined gear mechanism for the three right-ascension motors. The long shaft at the lower left connects to the main driving motor. Next in the train is the short camshaft (upper left) of the Gerrish drive timer. The large gear in the center is driven by a worm on the pulley shaft in the left foreground, which is operated by the slow-motion control motor, to accelerate or retard the clock mechanism while guiding on a star.

To the right of the same large gear is the set of four pinions that convert from the solar to the sidereal rate, using the

PRESENTING THE SENSATION OF 1960

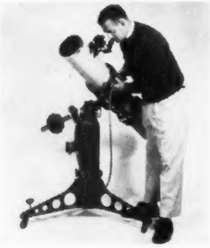
THE ★ ★ TRECKERSCOPE GALAXY ★ ★ SERIES

THE ULTRA-PRECISION EYE THAT REVEALS THE DRAMA OF THE LIVING UNIVERSE-- PRODUCED BY--

COAST INSTRUMENT THE ORIGINATOR OF "FIRSTS"!

The picture at the left illustrates the ease in using the new assistance light. This scientifically designed light will produce absolutely no night blindness, yet will allow reading of circles—star charts—ocular sizes—etc. with excellent non-glare illumination.

Remote Assistance Light



The picture at the left illustrates one of the finest features—The manual flex-line control! This exclusive COAST device allows vibrationless tracking when 110 volt current is not available. This is again only one of the star studded GALAXY of features found only in COAST INSTRUMENT products.

Using Our Exclusive Flex-Line Control

NEW DEVELOPMENTS

1. INSTANT LATITUDE ADJUSTMENT with rock-steady performance.
2. HYDRO-SMOOTH ROTATING-TUBE assembly, wonderfully smooth, a COMPLETELY NEW conception — only believable when in use!
3. Professional OPTI-SET* FINDERSCOPE, 50-mm. achromatic objective, 7-power helical-focusing eyepiece with crosshair reticle.
   *(Requires only 3-inch movement of head from finder to eyepiece, which is directly in line.)
4. BUILT-IN OCULAR RACK on each side of saddle holds eight eyepieces.
5. REMOTE ASSISTANCE LIGHT (illustrated in picture top right).
6. QUICK DETACH-ATTACH LEGS — absolutely ROCK-STEADY — come equipped with removable casters (wheels) and leveling screws.
7. Four-way POSITIVE-ADJUSTMENT spider (four vane).
8. NEW PORTABILITY — only 70 SECONDS to assemble or disassemble entire scope for field trips.
9. APPEARANCE — so strikingly different it beggars description! Dusk-charcoal mount, fiberglass tube with galactic blue, indestructible, stainproof finish.

SCIENTIFIC ACCESSORIES AVAILABLE AT EXTRA CHARGE.

- Frequency control console — transistor-powered for varying speeds of motor clock drive.
- Camera adapter (will fit any camera).
- Star spectroscope (5-prism type).

Write for additional information.

OUTSTANDING FEATURES

- 20-YEAR UNCONDITIONAL GUARANTEE.
- GUARANTEED TO RESOLVE TO (OR SURPASS) DAWES' LIMIT on nights of good seeing.
- GUARANTEED OPTICS. 1/10th and 1/20th wave of sodium light.
- FINEST OCULARS AVAILABLE (ORTHO-STARS). Your choice of any three sizes: 6.6 mm., 10 mm., 16 mm., 20 mm., 26.6 mm.
- CLOCK DRIVES — our regular synchro-smooth drive, and the sensational micro-adjust drive (as shown in illustrations); instant corrections can be made in either direction when electric drive is in operation.

FIELD TESTED FOR 14 MONTHS UNDER ALL CONDITIONS . . .

WRITE FOR LAB SPECIFICATION SHEET

Prices

GALAXY 6"	$ 775.00
GALAXY 8"	$ 895.00
GALAXY 10"	$1295.00
GALAXY 12.5"	$1495.00

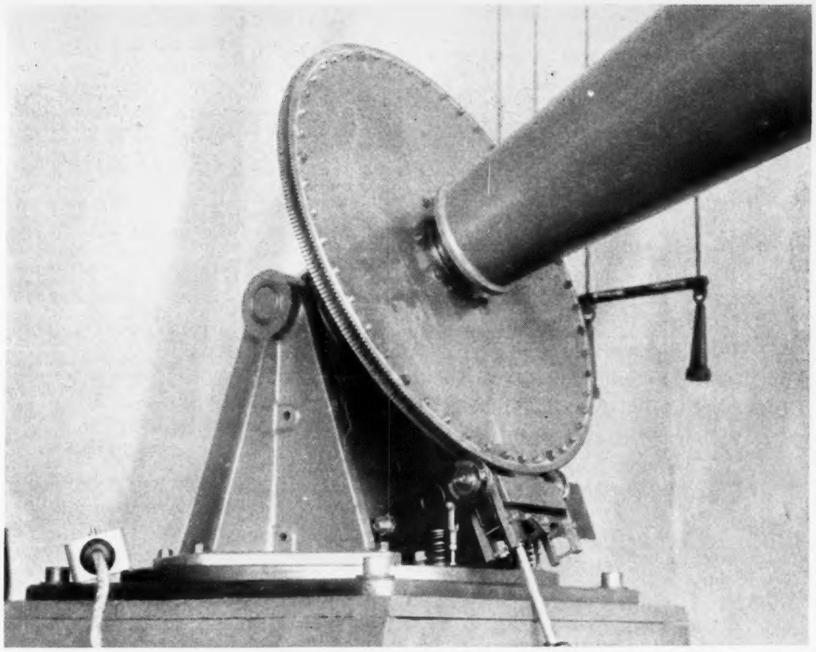
TAKE MONTHS TO PAY—6, 12, 18, OR 24—IF DESIRED, ON OUR EXTENDED PAYMENT PLAN.

SEND FOR OUR 68-PAGE CATALOG showing many of the other telescope items manufactured or distributed by COAST INSTRUMENT. It includes "WHAT YOU SHOULD KNOW, LOOK FOR, AND DEMAND, **BEFORE BUYING ANY TELESCOPE**," an impartial, informative article that will give you information you've probably been looking for to help make up your mind as to just what telescope you should buy!

All prices and specifications subject to change without notice. Prices, unless otherwise indicated, are at our warehouse in Long Beach, California. Shipping and nominal crating charges are added. California residents: add 4% sales tax to all prices. **NOW APPOINTING DEALERSHIPS — INQUIRIES INVITED.**
TRECKERSCOPES ARE CUSTOM MADE IN AMERICA BY PROFESSIONAL OPTICIANS AND ENGINEERS.

COAST INSTRUMENT, INC.
"IN OPTICS SINCE 1933"

4811 Long Beach Blvd., Long Beach 5, Calif.
Phone: GArfield 2-3411 or NEvada 6-7683



The north end of the polar axis, with springs supporting the worm mounting.

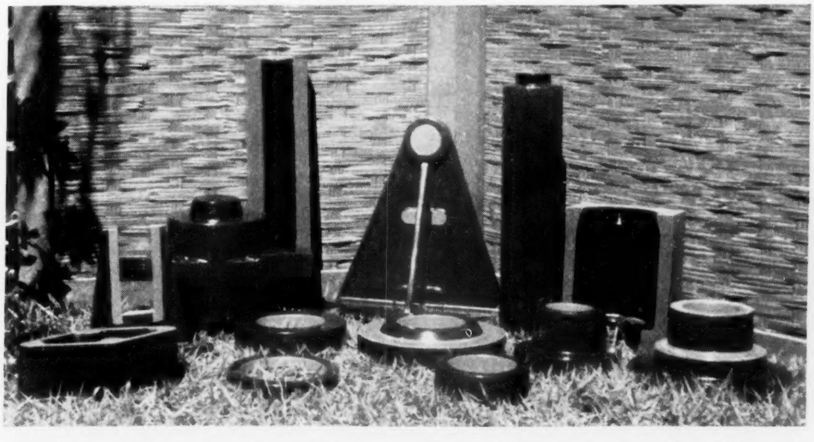
ratios $51/98 \times 79/41$, the output being transferred to the vertical spindle assembly. The horizontal worm wheel that this carries is driven by the worm on the shaft at the right, coupled to the slewing drive motor. Application of this rapid motion is made possible, while the sidereal drive continues to run, by means of the set of differential gears higher on the vertical assembly. The final output to the telescope's large ring gear is through the heavy shaft extending upward out of the picture.

All three motors are operated remotely from a portable control box, as are the slow motion and slewing in declination. The motors for the latter are similar to those used in the right-ascension drive and are located in the declination-axis counterweight housing. The main declination gear and worm are like the ones used on the polar axis.

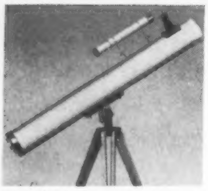
Remote indication of the position of the telescope is effected by coupling two Selsyn transmitters directly to the worm shafts driving the two axes. As the gears have 360 teeth, one revolution of the worm shaft is equivalent to one degree of movement in declination or four minutes of time in right ascension. Two optional remote indicators are provided, one an odometer type and the other a clock-face type.

The optical work, diagonal, eyepiece support assemblies, and some other features of this instrument will be described next month.

BRADLEY H. YOUNG
P. O. Box 822
Los Altos, Calif.



Casting patterns for some of the mounting parts are assembled here for a color photograph from which this reproduction is made. The two patterns at the extreme left are for the south trunnion fitting, and the triangular one in the center is for the north trunnion.



3-inch Astronomical Reflector

60 to 180 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

FREE with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."**

Stock #85,050-Y .... $29.95 ppd.

OFFSPRING OF SCIENCE . . . REALLY BEAUTIFUL!

CIRCULAR DIFFRACTION-GRATING EARRINGS AND CUFF LINKS

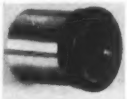
A Dazzling Rainbow of Color!

As a scientific phenomenon, a conversation piece, and fascinating personal accessory, this new kind of jewelry is capturing attention everywhere. Shimmering rainbows of gemlike color in earrings and cuff links of exquisite beauty — made with CIRCULAR DIFFRACTION-GRATING REPLICA. Just as a prism breaks up light into its full range of individual colors, so does the diffraction grating. Promises to become a rage in current fashion.

Stock #30,349-Y . . Earrings (clip style) Tax Incl. **$2.75 ppd.**
Stock #30,350-Y . . Cuff Links ..... Tax Incl. **$2.75 ppd.**

Just Arrived!

STANDARD 4-mm. ORTHOSCOPIC EYEPIECE



These are best for extremely high magnification (300 power with a 48"-f.l. objective). You get a wide, flat field — almost 3 times as much field as a Ramsden of the same power — excellent color correction and definition. Precision made of brass, chrome plated and black enameled. Inside is dead-black anodized with anti-glare shield.

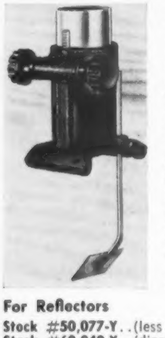
Stock #30,364-Y .... Only **$14.50 ppd.**

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner eyepiece, type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y .... **$7.95 ppd.**

Rack & Pinion Eyepiece Mounts



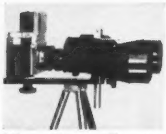
Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors
Stock #50,077-Y . . (less diagonal holder) .... **$8.50 ppd.**
Stock #60,049-Y . . (diagonal holder only) .... **1.00 ppd.**

For Refractors
Stock #50,103-Y . . (for 2⅞" I.D. tubing) .... **12.95 ppd.**
Stock #50,108-Y . . (for 3⅞" I.D. tubing) .... **13.95 ppd.**

NEW BINOCULAR-TO-CAMERA HOLDER

For Exciting Telephoto Shots
Will fit any camera.

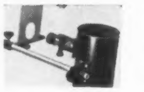


Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our NEW BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing the constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephotos included.

Stock #70,223-Y .... **$11.50 ppd.**

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES

Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!



SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

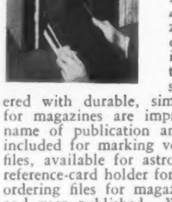
Stock #70,162-Y .... **$9.95 ppd.**

STANDARD 1¼" EYEPIECE HOLDER

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y .... **$2.50 ppd.**

NEW! BOX FILES FOR MAGAZINES, ASTRONOMICAL DATA, BULLETINS



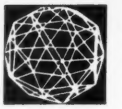
Keep your back issues of *Sky and Telescope* and other magazines, photos, or astronomical data safe from dust and damage in handsome, sturdy box files that are sized to fit! Files resemble hand-bound books, covered with durable, simulated-leather material. Files for magazines are imprinted in real gold leaf with name of publication and year published. Gold foil included for marking volume or issues in file. Other files, available for astronomical data or photos, have reference-card holder for description of contents. When ordering files for magazines, give name of periodical and year published. When ordering files for other materials, give dimensions needed — height, depth, width (max. width 5"). Minimum order is two.

Stock #19,018-Y . . . 2 files, same or assorted sizes .... **$5.00 ppd.**

Quantity prices: 3 files, **$7.00 ppd.**; 6 files, **$13.00 ppd.**; 50 or more, **$2.00 each, ppd.**

D-STIX Construction Kits

Shape Your Ideas Fast!



Scientists, executives, planners, designers — all find D-STIX simplify visualization and demonstration of complex ideas. D-STIX — colored wood sticks ⅛" thick and "easy-on" rubber joints approx. 3/16" diam. — help you work out molecular structures, geometric figures, structural members, shapes, models of scientific apparatus. Used by professional men, educators, hobbyists. Big basic kit contains 230 or 370 pieces. Additional parts in supplementary kit. Far superior to other kits of wood or metal. Money-back guarantee.

Stock #70,209-Y .... (230 pieces) .... **$3.00 ppd.**
Stock #70,210-Y .... (370 pieces) .... **$5.00 ppd.**
Stock #70,211-Y .... (452 pieces) .... **$7.00 ppd.**

TELESCOPE ROLL-FILM CAMERA

This model uses rolls of #127 film. Picture area will be a circle 1-9/16" in diameter.

The advantage of this model is the ease of using roll film. With each camera you get a piece of ground glass. Before loading film in the camera, you focus the telescope. Then lock it in this position. For positions other than infinity, you can scribe a mark on your tube.

Stock #70,182-Y .... **$29.50 ppd.**

SHEET-FILM CAMERA

Uses sheet film 2¼" x 3¼" size. Camera box size is 3" x 4" x 5".

Stock #70,166-Y .... **$39.50 ppd.**

ASTRO COMPASS and STAR FINDER

Gov't. Cost $75 — Price $14.95 ppd.

Determines positions of stars quickly. Shows various celestial co-ordinates. An extremely useful star finder which can be rotated through 60° angles along calibrated degree scale. Has single eye lens with viewing stop, two spirit levels for aligning, tangent screw with scale for fine precision readings, azimuth scale graduated in two-degree intervals, adjustable tilting azimuth scale for angle reference of stars on distant objects. War surplus. Gov't. cost $75.00. Instructions, carrying case included.

Stock #70,200-Y .... Only **$14.95 ppd.**

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y .... **$8.00 ppd.**

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y .... **$12.00 ppd.**

AMICI PRISM STAR DIAGONAL

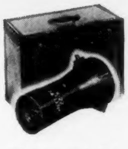
Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to right and left, making it excellent for terrestrial viewing.

Stock #50,247-Y .... **$12.00 ppd.**

EDMUND SCIENTIFIC CO.

SALE! TERRIFIC WAR-SURPLUS BARGAINS!

AERIAL CAMERA LENSES



Big variety . . . at a fraction of Gov't. cost! f/6, 24" f.l., with diaphragm and lens cone. Used. Weight 25 lbs.
Stock #85,059-Y . . $39.50 f.o.b. Utah

Same as above, but new. Weight 25 lbs.
Stock #85,060-Y . . $59.50 f.o.b. Utah

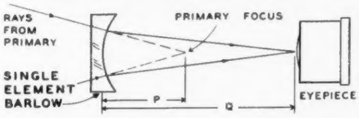
f/8, 40" f.l., no mount or shutter. Weight 6¼ lbs.
Stock #70,186-Y........................$49.50 ppd.

f/5.6, 20" f.l., telephoto with shutter and diaphragm. Weight 6¼ lbs.
Stock #70,187-Y........................$65.00 ppd.

f/4.5, 6⅜" f.l., with shutter and diaphragm. Weight 1 lb., 6 ozs.
Stock #70,189-Y........................$24.50 ppd.

These lenses are being successfully used for wide-aperture Moonwatch telescopes to see the small and fainter satellites. For eyepiece use our GIANT ERFLE.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.
Stock #30,200-Y . . . Mounted Barlow lens . . . . $8.00 ppd.

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length −1-5/16", unmounted.
Stock #30,185-Y . . . . 0.932" diam...........$3.50 ppd.
Stock #30,328-Y . . . . 0.912" diam...........$2.50 ppd.

3X ADJUSTABLE-DIAMETER BARLOW LENS

For telescopes with eyepieces smaller than the standard 1¼" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" outer diameter. Directions for using included.
Stock #30,339-Y $5.00 ppd.

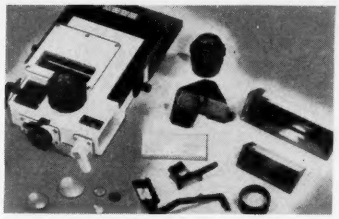
8" SETTING-CIRCLE SET

Stock #50,133-Y . . Complete set .... $3.00 ppd.
Stock #60,078-Y . . 360° declination circle only $1.60 ppd.
Stock #60,079-Y . . 24-hour right-ascension circle only $1.60 ppd.

5¾" SETTING-CIRCLE SET

Stock #50,190-Y . . Complete set .... $2.50 ppd.
Stock #60,080-Y . . 360° declination circle only $1.35 ppd.
Stock #60,081-Y . . 24-hour right-ascension circle only $1.35 ppd.

SPECIAL SALE OF OPTICAL PERISCOPES



We made a lucky buy, so here is another famous Edmund war-surplus bargain. It is a $500.00 tank periscope with over $200.00 worth of optics in it for only $18.00 postpaid. At one spot, you look through and see up and out of the prisms at unit power; or you can look through the built-in telescope system and see a wide-angle view at 6x. Simply remove the top prism and you have an 11°.3 6-power satellite telescope. *Brand new in original packages.* Over-all size is 14" long by 7" wide by 2½" deep.

Now just for the bit of work involved in disassembling, you get a treasure-trove of precision optical parts for only $18.00. Glance at this list of parts and you'll realize what a value we are offering. You get a wide-angle Erfle eyepiece with a full 68° field and 1¼" focal length. This is the same eyepiece used in Moonwatch telescopes, our Stock No. 5160. Also included are a 38-mm.-diam. collimator lens, 131-mm. focal length; 48-mm.-diam., mounted, coated objective lens, 189-mm. f.l.; prism cluster containing two light flint glass right-angle prisms (A, 41 mm.; B, 91 mm.; C, 64 mm.; and A, 41 mm.; B, 57 mm.; C, 40 mm.); two mounted right-angle prisms (A, 23 mm.; B, 34 mm.; C, 23 mm.; and A, 40 mm.; B, 42 mm.; C, 30 mm.); two silvered tank prisms (A, 102 mm.; B, 53 mm.; C, 38 mm.; and A, 167 mm.; B, 69 mm.; C, 49 mm.). (*See our catalog for explanation of these prism sizes.*) Also some other optical elements and reticles. Every amateur will find this a real value. Don't wait — order today. The last time we had these they sold for $30.00 — now on sale at only $18.00.
Stock #70,227-Y..$18.00 ppd.

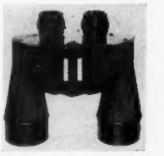
EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.
Stock #85,081-Y . . . . $76.50 f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.
Stock #85,023-Y . . . . . New Low Price . . . . . $39.50 f.o.b. Barrington, N. J.

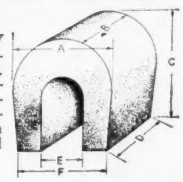
WAR-SURPLUS! AMERICAN-MADE!

7 x 50 BINOCULARS



Big savings! Brand new! Crystal-clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx. field at 1,000 yds. is 376 ft. Carrying case included. American 7 x 50's normally cost $195. Our war-surplus price saves you real money.
Stock #1533-Y......................Only $55.00 ppd. (Tax included)

GIANT MAGNETS! TERRIFIC BARGAINS!



War Surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 5 lb. size. Its dimensions: A — 3¼"; B — 2¾"; C — 4-3/16"; D — 1¼"; E — 1¼"; F — 2⅜". Strength is about 2,000 gauss. Will lift over 125 lbs.
Stock #70,183-Y........................$8.50 ppd.

15¾-lb. size magnet. Approximately 5,000-6,000-gauss rating. Will lift over 250 lbs.
Stock #85,088-Y........................$22.50 f.o.b.
Shipping wt. 22 lbs. Barrington, N. J.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.
Stock #30,204-Y . . . . . ¼" focal length . . . . . $4.75 ppd.
Stock #30-203-Y . . . . . ½" focal length . . . . . $4.50 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

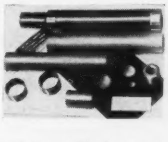
The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.
Stock #50-074-Y........................$16.25 ppd.

GIANT ERFLE EYEPIECE

Here is an exciting bargain. We obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the space age.
Stock #50,178-Y........................$9.95 ppd.

Attention! For Beginners, Junior Astronomy Clubs, Boy and Girl Scouts, Camp Groups, School Science Clubs

MAKE 8-POWER ASTRONOMICAL TELESCOPE with Low-Cost Beginner's Kit!



Every boy and girl of today dreams of being a part of the exploration of outer space. That desire makes building his own telescope a real thrill. Now anyone of Cub Scout or Brownie age on up can make his own astronomical 8-power telescope in one evening, without tools or machinery. Here is an ideal, attractive group project for scouts, junior astronomy clubs, or similar groups. (See special quantity prices.) Scope is powerful enough to show craters of the moon, Jupiter's satellites, and many stars not visible to the naked eye. Kit includes objective lens, field lens, eye lens, glare stops, kraftboard tubes, cadmium-plated metal ferrules, and other parts to build an 18"-long, 1¾"-diameter telescope of 8 power.
Stock #70,238-Y........................$3.00 ppd.

SPECIAL QUANTITY PRICES

Stock #70,239-Y . . . . 5 kits..............$12.50 ppd.
Stock #70,240-Y . . . . 10 kits..............$22.50 ppd.

BE SURE TO GET FREE CATALOG "Y"

128 Pages! Over 1000 Bargains!

Fantastic variety — rarely before have so many lenses, prisms, optical instruments, and components been offered from one source. Probably the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids.
Write for Free Catalog "Y".

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

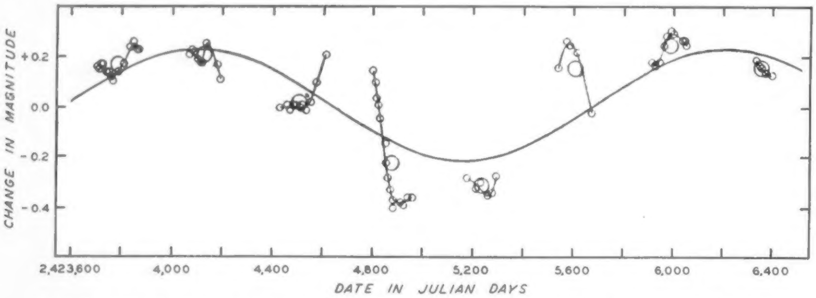
BETELGEUSE

ALPHA ORIONIS, the 1st-magnitude red star in Orion's shoulder, varies in brightness, a fact first noted by Sir John Herschel in 1836. Even casual observation may show that in some years it is nearly as bright as Capella, in others as faint as Pollux.

Sometimes Betelgeuse scarcely changes for several months, but often it may vary by some tenths of a magnitude within a few weeks. The American astronomer Joel Stebbins found that, in addition to these irregular fluctuations, there is a well-marked six-year cycle.

Amateurs who wish to make naked-eye estimates of the brightness of Betelgeuse may use these comparison stars: Capella (α Aurigae), +0.1; Rigel (β Orionis), +0.2; Procyon (α Canis Minoris), +0.4; Aldebaran (α Tauri), +0.8; and Pollux (β Geminorum), +1.2. The visual magnitudes are based on photoelectric data by Harold L. Johnson and taken from his list of the 50 brightest stars in SKY AND TELESCOPE for August, 1957, page 470.

In estimating Betelgeuse, use only comparison stars that are at approximately the same altitude above the horizon as it is. Otherwise, atmospheric extinction can cause large errors. Rigel and Aldebaran are less suitable than the other comparison objects. The former differs greatly in color from Betelgeuse, while the latter varies by 0.2 magnitude.



Joel Stebbins' photoelectric light curve of Betelgeuse, 1921-31. The horizontal scale is in Julian days. From the "Publications" of Washburn Observatory.

MINOR PLANET PREDICTIONS

Thalia, 23, 9.5. February 6, 11:05.6 +26-07; 16, 10:58.9 +27-30; 26, 10:50.1 +28-28. March 7, 10:41.0 +28-57; 17, 10:33.2 +28-53; 27, 10:27.9 +28-14. Opposition on February 29.

Amphitrite, 29, 9.9. February 26, 12:20.6 −1-46. March 7, 12:12.9 −1-20; 17, 12:03.8 −0-46; 27, 11:54.4 −0-10. April 6, 11:45.6 +0-23; 16, 11:38.5 +0-48. Opposition on March 20.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

Vesta, 4, is the brightest of the asteroids, and will be readily visible in binoculars during most of this year. At opposition, on July 2nd, its visual magnitude will be 5.7. In mid-February the magnitude is 7.5; by the end of March, 7.0; and in early May, 6.5.

The following predicted positions are for the epoch 1950.0, and have been abridged from the *American Ephemeris:*

February 6, 17:02.0 −17-55; 16, 17:21.2 −18-20; 26, 17:39.7 −18-35. March 7, 17:57.2 −18-43; 17, 18:13.5 −18-45; 27, 18:28.5 −18-43. April 6, 18:41.8 −18-38; 16, 18:53.2 −18-34; 26, 19:02.2 −18-32. May 6, 19:08.6 −18-38.

VARIABLE STAR MAXIMA

February 5, U Ceti, 02281**3**, 7.5; 7, R Reticuli, 043**263**, 7.6; 7, RT Cygni, 194048, 7.3; 8, S Gruis, 221**948**, 7.7; 9, R Andromedae, 001838, 7.0; 11, T Columbae, 051**533**, 7.5; 11, X Centauri, 114**441**, 8.0; 15(?), T Sagittarii, 190**117**, 8.0; 17, T Cassiopeiae, 001755, 7.8; 18, V Coronae Borealis, 154639, 7.5; 20, W Lyrae, 181136, 7.9; 21, S Pegasi, 231508, 8.0; 25, S Pavonis, 194**659**, 7.2; 25, T Pavonis, 193**972**, 8.0; 29, R Horologii, 025**050**, 6.0.

March 6, R Serpentis, 154615, 6.9; 6, T Centauri, 133**633**, 5.5; 7, R Canum Venaticorum, 134440a, 7.7; 9, R Ophiuchi, 170**215**, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCE

First quarter	February	4, 14:27
Full moon	February	12, 17:24
Last quarter	February	19, 23:48
New moon	February	26, 18:24
First quarter	March	5, 11:06

February	Distance	Diameter
Apogee 7, 6^h	251,800 mi.	29′ 30″
Perigee 23, 3^h	228,300 mi.	32′ 31″
March		
Apogee 6, 2^h	251,300 mi.	29′ 33″

MINIMA OF ALGOL

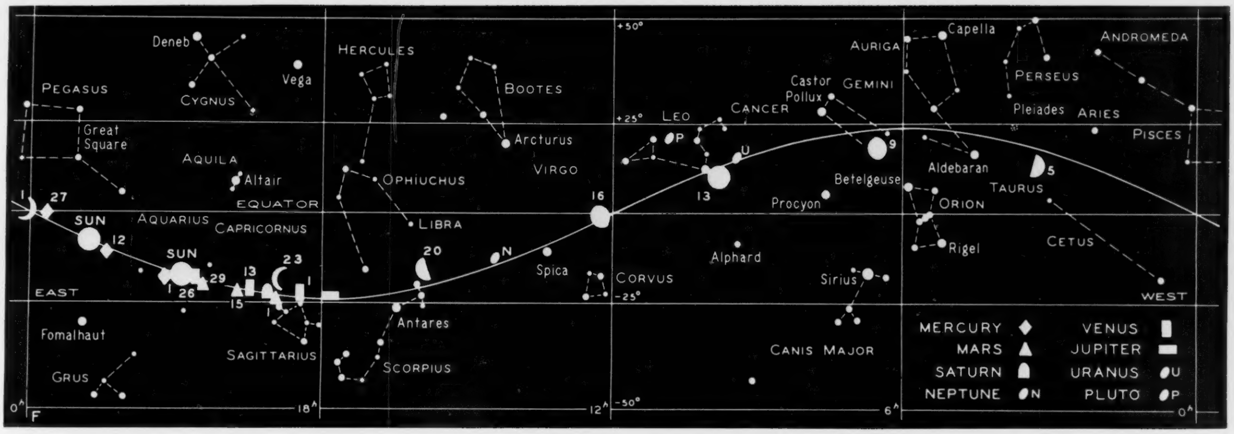
February 3, 8:12; 6, 5:02; 9, 1:51; 11, 22:41; 14, 19:30; 17, 16:19; 20, 13:08; 23, 9:58; 26, 6:47; 29, 3:36.

March 3, 0:26; 5, 21:15; 8, 18:04.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of the star's least brightness.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury will be well placed for evening observing in midnorthern latitudes during the latter half of February. On the 24th, it reaches greatest eastern elongation 18° from the sun, then being of magnitude −0.1. It should be readily visible for about 10 days before and a week after elongation.

On February 18th, a line along the western side of the Great Square of Pegasus, from Beta to Alpha Pegasi, can be extended southward an additional 1½ times its length to end very close to Mercury, which will then be of magnitude −0.8, about twice as bright as at greatest elongation a week later. On February 24th, however, astronomical twilight will end as Mercury sets, 1½ hours after the sun, so the planet may be seen in a nearly dark sky. Thereafter, its position will change little, forming a nearly equilateral triangle with the stars Alpha and Gamma Pegasi, in the south side of the Great Square.

In a telescope on February 24th, Mercury's phase will resemble the quarter moon's. Information about observing this planet is given on page 221 of this issue.

Venus in midmonth is visible in the predawn sky as a brilliant object of magnitude −3.4, rising in the southeast about 1½ hours before the sun. On the 15th, the disk is 84.3-per-cent illuminated and 12″.6 in diameter. On the morning of February 7th, Venus will be only 0°.2 north of Saturn, conjunction occurring at 11^h Universal time. Venus will pass about 1° north of Mars at 3^h UT on the 17th.

Mars rises about 1½ hours before the sun on the 15th, but will be difficult to locate since it is faint (magnitude +1.5) and low in the southeast. Look for Mars in binoculars when it is in conjunction with Venus on the morning of February 17th.

Jupiter is in western Sagittarius, well placed in the morning sky before dawn. Its magnitude is −1.5, so it will make a striking sight with the moon 5° north on the morning of February 22nd. Telescopically, Jupiter's disk is 34″.2 in equatorial diameter, 31″.9 in polar.

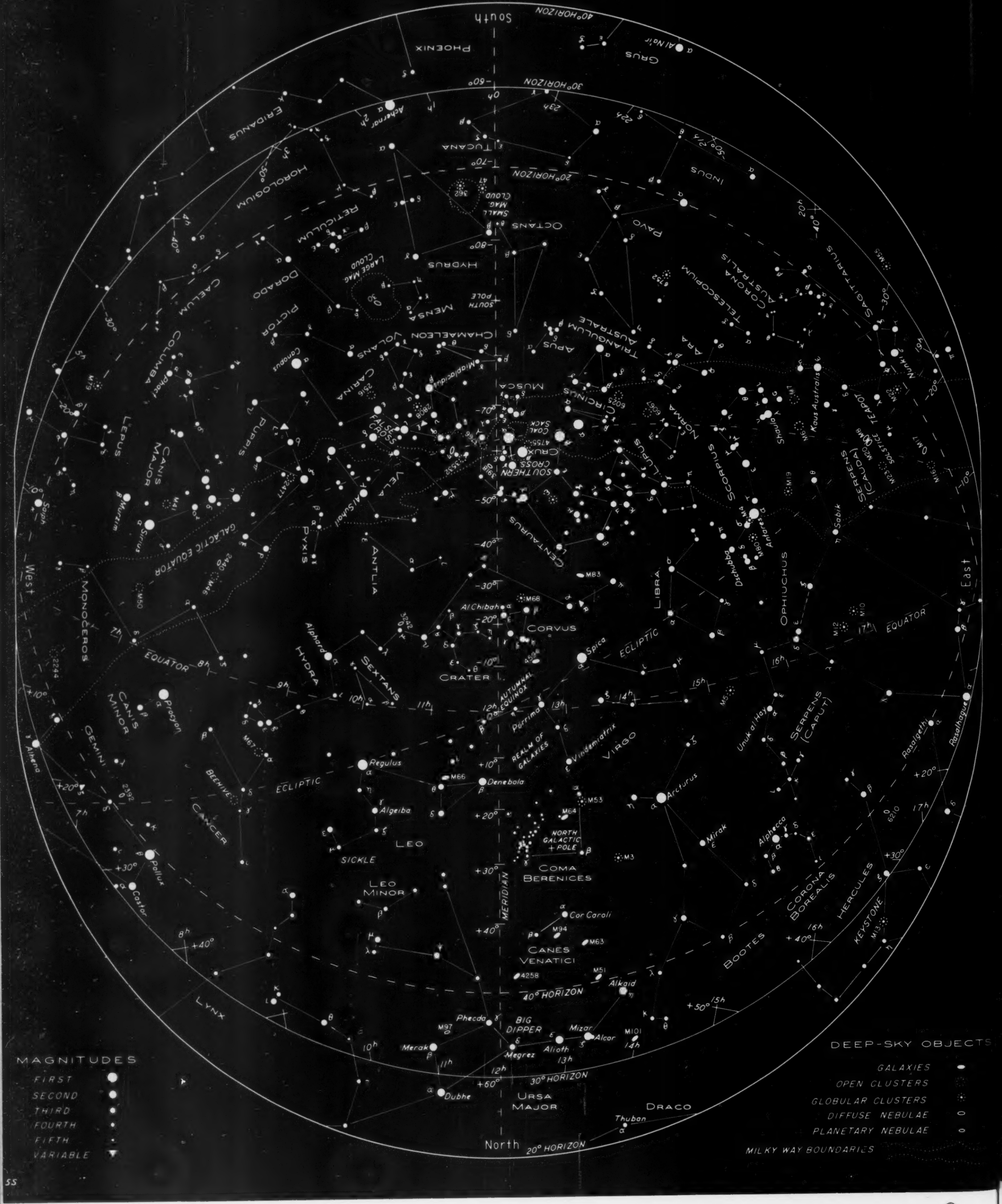
Saturn rises about two hours before the sun, being in Sagittarius east of Jupiter. It is visible low in the southeastern dawn sky as a 1st-magnitude object.

Uranus reaches opposition to the sun on the 8th, 1.6 billion miles from the earth. It then shines at magnitude 5.7, rising about sunset and visible all night. Its path in Leo is given in the chart published last month on page 191. On the date of opposition, the right ascension and declination of Uranus are 9^h $26^m.3$, +15° 52′ (1950 co-ordinates).

Neptune is in the southeastern sky during early morning hours. A small telescope is needed to see this 8th-magnitude object, located in western Libra, as shown in the chart on page 191 of the January issue. Neptune is stationary in right ascension on February 10th, beginning retrograde (westward) motion among the stars.

Pluto comes to opposition on the 24th, three billion miles from the earth. Large telescopes are needed to show this 15th-magnitude planet in Leo, at 10^h $46^m.3$, +21° 32′ (1950).

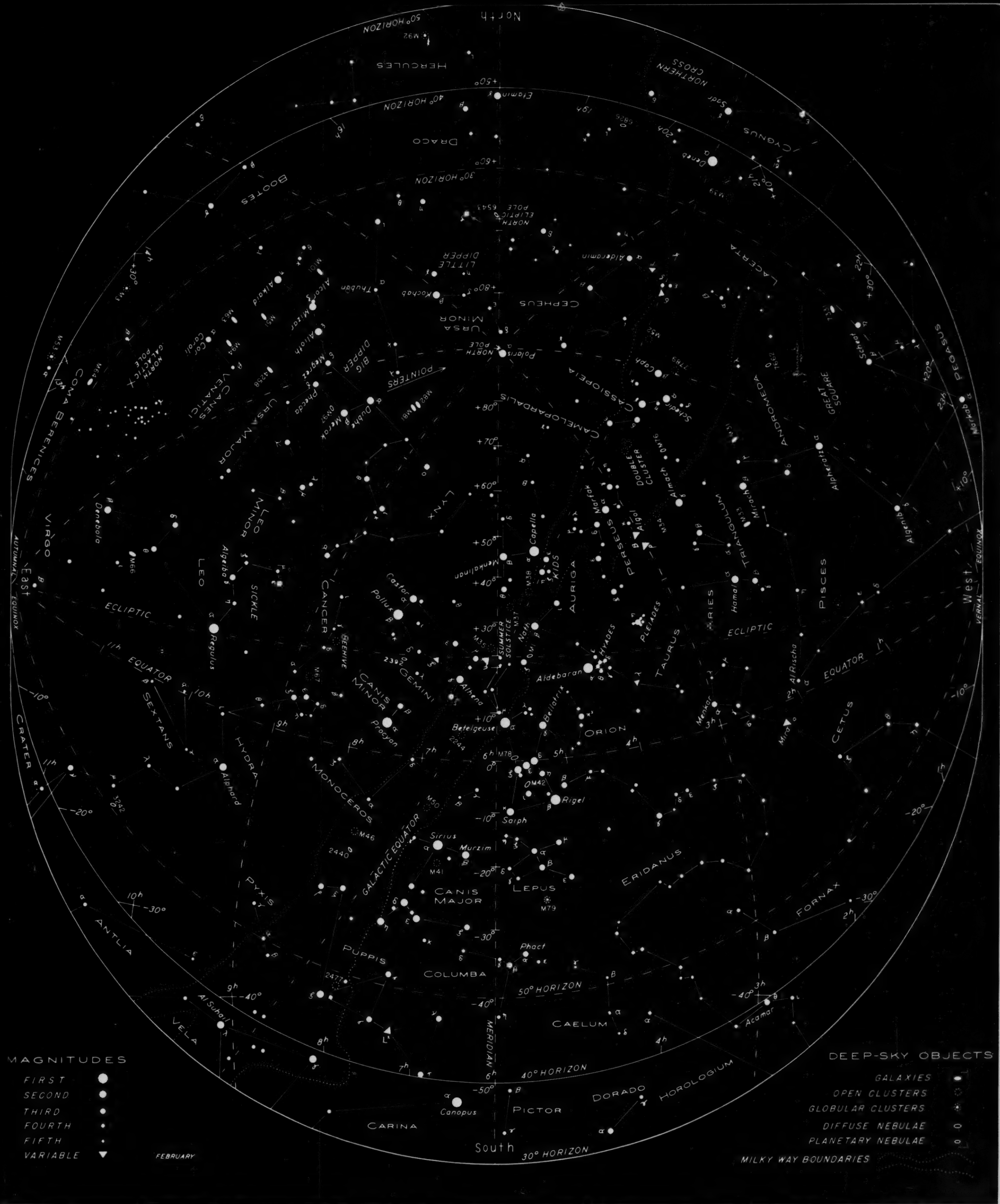
W. H. G.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 22nd of April; also at 9 p.m. and 8 p.m. on May 7th and 22nd. For other dates, add or subtract ½ hour per week.

The three horizon circles on both the northern and southern star charts make the maps usable over a wide range of latitudes, and also aid when the observer is visualizing the form of a constellation that is only partly above the horizon at a particular time.



STARS FOR FEBRUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 21st of February, respectively; also at 7 p.m. and 6 p.m. on March 7th and 23rd. For other dates, add or subtract ½ hour per week.

When facing north, hold "North" at the bottom; turn the chart accordingly for other directions. The equator, ecliptic, galactic equator, and meridian are indicated by dashed curves, as are the hour circles that are three and six hours east and west of the meridian.

PRINTED BY WELLESLEY PRESS, INC.

Equatorial mounting of the 4" UNITRON refractor, Model 152.

Step up, friend. Sit yourself down at the controls of a UNITRON. Feel the sure response of the slow-motion controls. Note the extra-smooth handling ease. Observe the oversize components, which give UNITRON mountings strength to spare.

If it's an altazimuth model, you have micrometric adjustments for both altitude and azimuth. In the equatorial models, you'll find the mechanism more sophisticated — but the operation is even easier. Here, once you've pinpointed your target, only the single right-ascension control is needed to keep the object centered in the field of view. You'll welcome the added convenience of the new flexible cable extension which brings the right-ascension control within easy reach — a new feature included with all UNITRON equatorials as standard equipment.

Note, too, the precise slow-motion adjustment for declination. Scrutinize the precision gears designed to deliver generations of velvet-smooth performance. Examine the large easy-reading setting circles and verniers provided on the 3" and larger models.

(What you won't see is the instrument's complex of inner workings — a blend of the arts of the artillery engineer and the Swiss watchmaker that gives you an instrument whose response will be obedient to the slightest touch of your fingers.)

And — while you're at it — don't forget to look through the refractor. UNITRON's optical excellence is the other big reason UNITRON sales are mounting.

Sturdy altazimuth mounting with slow-motion controls as well as rapid motions for altitude and azimuth.

UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO. — 204-206 MILK STREET, BOSTON 9, MASS.

SEE PAGES 244 AND 245 FOR MORE ABOUT UNITRON.